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INDOOR-OUTDOOR AIR LEAKAGE OF APARTMENTS AND COMMERCIAL BUILDINGS: APPENDICES

PIER FINAL PROJECT REPORT

Prepared For:

California Energy Commission
Public Interest Energy Research Program

Prepared By:
Lawrence Berkeley National Laboratory

December 2006
CEC-500-2006-111-AP

Indoor-Outdoor Air Leakage in Apartments and Commercial Buildings

The accompanying MAIN report is available at

www.energy.ca.gov/2006publications/CEC-500-2006-111/CEC-500-2006-111.PDF

Appendix A

Air Infiltration Model for Large Buildings

APPENDIX A: AIR INFILTRATION MODEL FOR LARGE BUILDINGS

The body of this report contains data and discussion of the leakage parameter in commercial buildings. The leakage parameter quantifies the air flow through the building shell for a given indoor-outdoor pressure difference. A natural question is how these leakage parameters are related to the amount of air flow across the building shell in normal operation, when the pressure drop across the building shell varies due to wind and due to temperature differences between indoors and outdoors. This appendix describes the best currently available model for predicting the air flow from the leakage parameter, wind speed and direction, and indoor-outdoor temperature difference.

Driving Forces for Air Infiltration

With mechanical ventilation systems off, the driving forces for air infiltration through the building envelope are wind, which exerts pressure on walls, and indoor-outdoor temperature difference, which induces "stack flow" in the building. The windward side(s) of the buildings will be over-pressurized and other side(s) will be under-pressurized. Further, the vertical distribution of pressure differences can be significant for tall buildings. The interaction between stack and wind driven flow can also be potentially different. All these factors make estimation of air infiltration rates more complex.

Multizone models are commonly used to predict airflow in large indoor spaces. In such models, a building is represented as a collection of well-mixed spaces linked by flow paths (Lorenzetti, 2002). These models can calculate the zone-to-zone flows, as well as estimate infiltration and exfiltration rates across the building envelope. However, multizone models are very data intensive to apply (Persily and Ivy, 2001; Price et al., 2004). Not only are the air leakage characteristics of the building envelope needed, but the air leakage characteristics of each internal flow path also need to be known. This requires more detailed knowledge than the floor plan and ventilation duct configuration of the building. Furthermore, the wind-pressure coefficients on all building façades as a function of the wind direction must also be specified. Because of the demanding data requirements, it is impractical to use a multizone model to predict the air infiltration rates on an ensemble of buildings.

Shaw-Tamura Infiltration Model

An alternative approach to multizone modeling is to focus on the building envelope across which infiltration occurs, and to conceptualize the internal partitioning and connectivity of a building as adjustment factors. Tamura and Shaw (1976) and Shaw and Tamura (1977) developed a method for calculating infiltration rates of tall buildings caused by wind and stack effect separately, based on the physics of fluid flow. Then, data from wind tunnel experiments were used to combine the two effects to give the overall air infiltration rates. Their model is outlined here.

Stack Effect

When the outdoor air is cooler than the indoor air, the denser outdoor air causes the vertical rate of change in pressure to be faster than the indoor. Near the roof of the building, the relatively lower outdoor pressure drives air to escape through the building envelope. Air infiltrates through the lower parts of the building to replace the exfiltrating air. The stack effect can be reversed in the summer time when the indoor temperature, T_i, is lower than the outdoor temperature, T_o. The pressure difference caused by the stack effect (ΔP_s) is:

$$\Delta P_s = \rho_o \cdot g \cdot \left(\frac{T_i - T_o}{T_i} \right) \cdot \left(H'' - h \right)$$

where ρ_o (kg/m^3) is the outdoor air density, and g = 9.8 m/s^2. H''(m) is the height where the indoor and outdoor pressure equals, which is often referred to as the neutral pressure height. When the indoor temperature is higher than the outdoor, infiltration occurs from ground level (h [m] = 0) up to H''. When the stack effect is reversed, infiltration occurs from the top of the building H (m) down to H''. In large buildings, many factors can affect the location of the neutral pressure level. These include internal partitions, stairwells, elevator shafts, utility ducts, chimneys, vents, operable windows, and mechanical supply and exhaust system. An opening with a large area relative to the total building leakage can cause the neutral pressure level to be pulled towards the positioning of the leakage element.

Large buildings also tend to have many internal partitions that can cause significant internal airflow resistance. In a building with airtight separations at each floor, each story will act independently such that the stack effect is discontinuous from floor to floor. In this case, stack effect induced infiltration for the building can be much less than that which would result from the theoretical stack effect. Further, the location of the neutral pressure height can also be affected. To quantify this effect, thermal draft coefficient, γ (-), is defined as the sum of the pressure differences across the exterior wall at the bottom and at the top of the building, divided by the total theoretical draft for the building. For a building without internal partitions, the total theoretical draft is achieved, and thus $\gamma = 1$. Conversely, when the air leakage of the internal partitions is much tighter than the exterior envelope, γ approaches 0.

The Shaw-Tamura Infiltration Model estimates the air infiltration rates driven by the stack effect, Q_s (m^3/s), by considering the amount of airflow on an incremental surface area dA (m^2) on the vertical walls of the building envelope. By assuming that the building has a uniform building perimeter with height, the incremental surface area can be expressed as the product of the building perimeter S (m) and the incremental height of the building dh (m). Starting with the power-law relationship between air-leakage coefficient and air infiltration rate, the total air infiltration rate driven by stack effect is the integral of dQ_s over the portion of the building envelope where infiltration occurs.

$$
\begin{aligned}
dQ_s &= C \cdot dA \cdot (\Delta P_s)^n \\
&= C \cdot S \cdot dh \cdot \gamma \cdot \left(\rho_o \cdot g \cdot \left(\frac{T_i - T_o}{T_i} \right) \cdot (H'' - h) \right)^n
\end{aligned}
$$

$$
\begin{aligned}
Q_s &= C \cdot S \cdot \gamma \cdot \left(\rho_o \cdot g \cdot \left(\frac{T_i - T_o}{T_i} \right) \right)^n \cdot \int_0^{H''} h^n \cdot dh \\
&= C \cdot S \cdot \gamma \cdot \left(\rho_o \cdot g \cdot \left(\frac{T_i - T_o}{T_i} \right) \right)^n \cdot \frac{(\beta \cdot H)^{n+1}}{n+1}
\end{aligned}
$$

where b [-] = H''/H. For example, $b = 0.5$ means that the neutral pressure level is at the mid-height of the building. The derivation assumes that air leakage is evenly distributed on the building envelope with respect to height. In other words, the air leakage coefficient C is assumed constant, and not a function of h.

Wind Effect

The pressure difference caused by the kinetic energy of wind impinging on the building envelope at U (m/s) is described by:

$$
\Delta P_w = C_p \cdot \frac{1}{2} \cdot \rho_o \cdot U^2
$$

where C_p (-) is known as the wind-pressure coefficient. As wind blows around a building, it generates areas of positive and negative pressure on the building envelope. Typically, the windward wall(s) will be pressurized with respect to the indoor, and the adjacent wall(s) may be depressurized. To reflect this, the value of C_p is different at each façade of the building. C_p can be measured using pressure taps on a model building in wind tunnel experiments or on real buildings in full-scale tests. Detailed airflow models would require C_p as a function of position on the different building façades to permit reliable predictions. For simplicity, the Shaw-Tamura Infiltration Model reduces these to one mean wind-pressure coefficient per façade, C_p', which is determined as the weighted mean of the pressure differences measured in wind tunnel experiments (Shaw and Tamura, 1977).

The wind-pressure coefficient, C_p', is a function of wind angle, shielding from surrounding structures, and terrain effects. The maximum pressure difference is observed on a building wall when the wind is approaching normal to it. The remaining three walls are typically depressurized when this happens. For a 45° wind-wall angle, two windward walls are likely to be pressurized at the same time, but the C_p' is lower in value. To account for this effect, a wind-angle correction factor, a, is defined as follows.

$$
\alpha = \left(\frac{C_p{'}_{\theta,1}}{C_p{'}_{0,1}} \right)^n + \frac{W}{L} \cdot \left(\frac{C_p{'}_{\theta,2}}{C_p{'}_{0,1}} \right)^n
$$

The subscript q is the wind angle impinging at the longer wall of the building, with $q = 0^o$ being normal to the wall. The next subscript is the wall number. Wall 1 is the longer wall by default. This equation assumes a rectangular-shaped building, so only wall 1 and wall 2 are considered explicitly. When the wind angle is 0^o, the maximum wind-pressure coefficient $C_{p\,0,1}^{'}$ occurs on the longer wall. In wind tunnel experiments, the ratios of mean wind-pressure coefficients are measured by the ratios of mean pressure difference on the envelope of the model building. L (m) and W (m) are the length and width of the building footprint. The ratio of these two lengths is needed to account for the wall area where infiltration occurs on the shorter wall (wall 2). The total air infiltration rate driven by wind effect on the building envelope is therefore:

$$
\begin{aligned}
Q_w &= C \cdot A \cdot \left(\Delta P_w\right)^n \\
&= C \cdot \left(L \cdot H\right) \cdot \alpha \cdot \left(C_{p\,0,1}^{'} \cdot \frac{1}{2} \cdot \rho \cdot U^2\right)^n
\end{aligned}
$$

In the Shaw-Tamura Infiltration Model, shielding is accounted for by direct adjustment to the mean wind-pressure coefficient. Conceptually, two factors are important in determining the appropriate mean wind-pressure coefficient to use. One is the plan area density (Grosso, 1992), a ratio of built area to total area within a certain radius from the considered building. The other is the relative building height, which is the ratio of the height of the considered building to the height of the surrounding buildings. Wind-pressure coefficients decrease with increasing plan area density, as more buildings can shield wind from impinging on the considered building. For a similar reason, wind-pressure coefficients decrease as the height of the surrounding building exceeds that of the considered building. Grosso (1992) presented a literature review on available wind tunnel data from which these observations are made.

Terrain roughness affects the vertical wind profile and the level of incident turbulence intensity on building walls. The power-law exponent of the wind profile, which describes how wind velocity changes as a function of vertical distance from a reference height, increases with increasing roughness of the surface. Wind-pressure coefficients are inversely related to the power-law coefficient as shown from wind tunnel experiments (Grosso, 1992). In a downtown urban area with enhanced surface roughness, the overall mean wind-pressure coefficients of buildings are expected to be lower than for buildings that are located in suburban areas.

Combined Stack and Wind Effects

The relative importance of the wind and stack driven air infiltration in buildings depends on a number of factors besides the strength of the respective driving forces, including building height, internal resistance to vertical airflow, location and flow resistance characteristics of envelope openings, local terrain, and the immediate shielding of the building. Tall, narrow buildings with little internal resistance to airflow are likely to have a strong stack effect. Unshielded buildings on a relatively smooth terrain are more susceptible to wind effects. For any building, there will be ranges of wind speed and temperature difference for which the amount of air infiltration is dominated by the wind effect, stack effect, or neither.

Shaw and Tamura carried out a few experimental studies to determine how the stack and wind effects combine to give the total air infiltration rate. Methods developed by Shaw and Tamura (1977) and by Shaw (1979) are the empirical formulations resulting from wind tunnel experiments using a tall building model. Shaw (1979) included the shielding effect from lower structures of uniform height that surround the tall building being studied; this study also investigated the influence of wind angle on the adjustment factor. Overall, the results obtained are within 20% of the predictions by method Shaw and Tamura (1977), which did not include shielding from surrounding structures, nor the wind angle effect.

$$\text{(i)}\quad Q_{\text{total}} = Q_{\text{large}} \cdot \left(1 + 0.24 \cdot \left(\frac{Q_{\text{small}}}{Q_{\text{large}}}\right)^{3.3}\right)$$

$$\text{(ii)}\quad Q_{\text{total}} = \begin{cases} Q_{\text{large}} \cdot \left(1 + \left(-0.0074 \cdot \theta + 0.39\right) \cdot \left(\frac{Q_{\text{small}}}{Q_{\text{large}}}\right)^{3.6}\right) & \text{for } 0^o \le \theta \le 45^o \\ Q_{\text{large}} \cdot \left(1 + \left(0.01 \cdot \theta - 0.48\right) \cdot \left(\frac{Q_{\text{small}}}{Q_{\text{large}}}\right)^{2.5}\right) & \text{for } 45^o \le \theta \le 90^o \end{cases}$$

$$\text{where: } Q_{\text{small}} = \min\left(Q_s, Q_w\right), Q_{\text{large}} = \max\left(Q_s, Q_w\right)$$

$$\text{and } \theta \text{ is in unit of degree } (^{\circ})$$

These relationships suggest that the total air infiltration rate is largely driven by either the stack or wind effect, whichever is higher. Only in the cases when both effects are similar in magnitude do the lesser terms also contribute significantly to the total air infiltration rate.

Shaw (1980) measured air infiltration rates at two school buildings in Canada, where the pressure differences were measured across the exterior walls at 7 locations continuously for 8 months. The stack and wind induced pressure difference were also computed using the Shaw-Tamura Infiltration Model, as described earlier. The computed sums of the wind and stack driven pressure differences were found to be good approximations of the overall pressure difference measured. According to this study, the relationship to obtain Q_{total} from Q_s and Q_w is:

$$\begin{aligned} Q_{\text{total}} &= C \cdot \left(\Delta P_s + \Delta P_w\right)^n \\ &= C \cdot \left(\left(\frac{Q_s}{C}\right)^{1/n} + \left(\frac{Q_w}{C}\right)^{1/n}\right)^n \\ &= \left(Q_s^{1/n} + Q_w^{1/n}\right)^n \end{aligned}$$

Other studies have observed relationships other than those presented here. For example, Fletcher and Johnson (1992) found that simple linear combination of wind speed and the square root of indoor-outdoor temperature difference is sufficient to explain the air infiltration rates variability observed in a small factory unit. This would imply adding Q_s and Q_w linearly to obtain Q_{total}. Experiments by Tanaka and Lee (1986) on a high-rise building found that the linear sum of pressure differentials owing to stack, wind, and forced ventilation is not the same as the overall pressure differentials measured. In practice, it is likely that no single empirical relationship would fit all buildings. Fortunately, differences in formulations are significant only when the stack and wind driven air infiltration rates nearly equal to one another. When either Q_s or Q_w is one half of the other or less, the different formulations give a total air infiltration rate that agrees within 20% of each other.

Air Infiltration Model Parameters and Uncertainties

Performance of air infiltration models often depends on whether site-specific information of the building being modeled is available. The Shaw-Tamura Infiltration Model has a number of adjustable parameters, namely the neutral pressure level (*b*), the thermal draft coefficient (*g*), the wind angle factor (*a*), and the wind-pressure coefficient (C_p'). A range of values is expected for each of these parameters in a group of buildings, which will contribute to the overall variability of the air infiltration rate predictions. If their distributions are known, their influences on the air infiltration rate predictions can be modeled. However, data on these input parameters are limited. Input parameters can also be time variant depending on the building operating conditions and the local meteorology. Discussed below are studies where these parameters have been measured. Even though the available data are insufficient to derive a representative distribution for each of the parameter, they do provide some indication of the range of values expected in real buildings.

Neutral Pressure Level and Thermal Draft Coefficient

All experiments were carried out when the mechanical systems were off. When pressure differential measurements were taken under various outdoor temperatures, it is found that *b* is unaffected by it. Sealing of air intake and exhaust dampers have shown to lower the neutral pressure level. The range of *b* observed is from 0.3 to 0.76, with mean = 0.48. Despite that the limited data do not suggest any particular distribution for the parameter, it is nonetheless reasonable to consider a possible range of *b* from 0.2 to 0.8, with the mean centering at 0.5. The two 1-storey schools measured by Shaw (1980) both has $b = 0.7$. It appears that there is no significant difference in terms of the vertical pressure differences distribution between high-rise and low-rise buildings.

The resistance to flow in the vertical direction is not high even in tall buildings. The thermal draft coefficient is in the range of 0.63 to 0.82. Both studies found that *g* is lower when the ventilation system is on, indicating higher flow resistance from floor to floor. Based on these very few data points, it appears the range of *g* is narrower than *b*. A reasonable range to consider is perhaps from 0.6 to 0.9, with the mean centering at 0.8.

Wind Angle Correction Factor and Wind-Pressure Coefficient

Pressure differential data from wind tunnel experiments and full-scale tests on buildings are more abundant. A review by Grosso (1992) summarizes the existing literature, models that compute wind-pressure coefficient distributions, and regression analysis of the wind-pressure coefficients measurements. The mean wind-pressure coefficients for adjacent sides of a building are out of phase by 90º with respect to wind angle (Shaw and Tamura, 1977; Shaw, 1979; Akins et al., 1979; Shaw, 1980). That is, wall 2 (shorter wall) has a mean wind-pressure coefficient at 90º wind angle that is roughly the same as wall 1 (longer wall) at 0º. At 45º, the two adjacent walls have roughly equaled mean wind-pressure coefficients that sum to the same total as when wind is approaching normal to a wall.

Mathematical models of the dependence of wind-pressure coefficients on wind angle are available (Grosso, 1992). However, to apply this dependence for a population of buildings will require detailed local wind data as well as information on the location and orientation of each building. The uncertainties associated with such inputs would be large. Favoring a simple model that can provide reasonable results without excessive needs for input data, the analysis to follow assumes that the wind always approaches normal to the long wall. In other words, a is assumed to be 1. This assumption tends to cause a slight overprediction of air infiltration rate when the building footprint has a very large aspect ratio. When the building footprint is close to square, the orientation of the building with respect to wind direction is less unimportant. This is true, however, only if air leakage is uniformly distributed on all walls of a building. The modeling approach here also assumes that all buildings have simple rectangular geometry.

Mean wind-pressure coefficients are also subject to local shielding and terrain. A review by Orme et al. (1994) summaries the dependence of wind-pressure coefficient on the height of surrounding structures relative to the building being modeled. The mean wind-pressure coefficient under heavy shielding, which occurs when the building is surrounded on all sides by obstructions of similar height, can be one-third the value when there is little obstruction surrounding the building. Wind-pressure coefficients are also subject to the overall building density in the vicinity of the modeled building: surrounding buildings can only affect the mean wind-pressure coefficients of the modeled building when they are in close proximity. Increasing the plan area density to 10 (i.e., the footprint area of the building is 10 times the effective area to its closest adjacent buildings. as measured by the product of the closest two distances between the modeled building and the adjacent building) from the no-shielding case can reduce the wind-pressure coefficients to half their unshielded value (Grosso, 1992).

Judging from existing wind tunnel and full-scale experiments (Akins et al., 1979; Grosso, 1992; Orme et al., 1994; Persily and Ivy, 2001), mean wind-pressure coefficients for the windward wall is typically in the range of 0.3 to 0.9.

References for Appendix A

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Appendix B

Analysis of Commercial Building Data

APPENDIX B: ANALYSIS OF COMMERCIAL BUILDING DATA

While the 267 building measurements used in this paper comprise the largest nonresidential air leakage collection to date, the data set is still too small to produce any meaningful conclusion using traditions analysis methods. Analysis is further complicated by the broad range of building types and locations within this data set. The measured buildings are located in five different countries, and include 12 different building usage types (schools, offices, etc.), and 7 different construction types (masonry, tilt-up, etc.).

The potential combinations from these three parameters (420) outnumbers the total numbers of building measurements (267) so some combinations are only represented by one or two measurements and other combinations to have no measurements at all. All combinations of building use, construction and location with relatively good representation show approximately lognormal distributions of building leakage, but the minimal data prevents performing a separate analysis on each combination in the data.

The entire data set, taken as a whole, also follows an approximately lognormal distribution (i.e., the logarithms of the data are distributed according to a Gaussian or "normal" distribution).

Simple approaches to data analysis would either (1) "pool" all of the data or large parts of it, by decreasing the number of building categories so that sample sizes in each category are increased, or (2) analyze each building category completely independently. The first approach would lump together data that should be kept separate, while the latter would fail to take into account any similarities between building types and would lead to severe problems with small sample sizes for many of the building categories.

"Bayesian Hierarchical Modeling" (also known as Bayesian Multilevel Modeling) provides a middle road, allowing partial sharing of information across categories. We will not attempt to explain Bayesian Hierarchical Modeling here, as it is a large subject and excellent reference materials are available (we recommend Gelman et al. 1995). Instead, we explain the basic concept of pooling of information.

Suppose we had a lot of data from, say, masonry schools, masonry office buildings, masonry retail stores, and masonry warehouses, so that we could estimate the statistical distribution of leakage for each of these building categories with very high accuracy. Further, suppose that the median leakage in each of these categories was very similar. In that case, even without seeing any data from masonry health care buildings, we would expect that the median educational building should be fairly close to that from the other categories. Now suppose we have just two data points concerning masonry health care buildings, and that the data points both show rather high leakiness. Although it's possible that masonry health care buildings tend to be leaky compared to all of the other types of masonry buildings, it's also possible that masonry health care buildings are about the same as the others and that we happened to sample two rather leaky buildings. If we know the amount of variability in leakage within a building category, and we know the amount of variation between building categories, then statistical methods can quantify how much information we get from two data points in a category and how much we get from the data concerning other building categories.

To implement this approach, we create a statistical model that describes what we think is happening with the data, and then use routine methods (implemented in a program called BUGS, for Bayes Using Gibbs Sampling) to fit the model to data. For our statistical model, we assume that buildings of a given construction type have some similarity to each other (with the degree of similarity to be determined by fitting the model), and that buildings of a given usage category have some similarity to each other (ditto), so that the log leakage of a building can be predicted from the sum of a "building usage coefficient" plus a "construction type coefficient" plus some other terms.

The model generates an estimate of a building's normalized air leakage from the sum of category coefficients as shown below:

$$\log(leakage) = \beta_{total} = \beta_{country_i} + \beta_{building\ j} + \beta_{construction_k} + \beta_{height\ m} + \beta_{footprint\ n} + \beta_{combo\ p}$$

The category variables determined from this analysis are presented in the tables below.

Beta Values

Each building characteristic (Country, Building-Type, Construction-Type, etc.) contains a group of coefficients, represented here as beta values. For example, there are five different beta values for the five possible countries where a building in the data may be located. Each "betaCountry" estimate represents the contribution of the country location on building leakage. The mean of the beta values is applied here as the best estimate of this contribution. The standard error in the table represents the uncertainty of this estimate. The median and the 2.5, 25, 75, and 97.5 percentiles are also presented to further quantify the uncertainty in the coefficient, since the uncertainty may not be normally distributed.

Sigma Values

Each building characteristic also contains a single sigma value that represents the variability of beta values within a building characteristic. For example, the “sigmaCountry” value represents the variability between the all possible betaCountry values, thus defining the normal distribution from which all the betaCountry values are assumed to be drawn. The sigma values are not of direct interest, but are an intermediate modeling parameter.

Example

Leakage for a building with a set of building characteristics is estimated as the sum of the appropriate beta values. For example, the leakage for a large, single story, masonry built school located in the U.S. would be calculated from the following beta values. From the country effect table, the beta value for the U.S. (betaCtry[1]) would be chosen. The beta value for education (betaBldg[1]) would be chosen from the building effect table. The beta values for masonry (betaConst[1]), single story (betaFN[1]), and for a large footprint (betaFP[2]) would also be chosen. A final beta value for the combination of country, building-type, and construction-type would then be chosen (betaCombo[1]). This final beta value acts as an error parameter by accounting for leakage differences in different combinations of building characteristics that may not have been predicted by the previous beta values. The sum of the chosen beta values represents the estimated log of leakage for a building with this particular set of characteristics.

$$
\begin{array}{lcl}
\text{United States} & = \beta_{country_1} & = 0.445 \\
\text{Education} & = \beta_{building_1} & = -0.080 \\
\text{Masonry} & = \beta_{construction_1} & = -0.008 \\
\text{Single Story} & = \beta_{height_1} & = 0.019 \\
\text{LargeFootprint} & = \beta_{FP_2} & = 0.046 \\
+\ \text{US - Edu - Masory} & = \beta_{combo_1} & = -0.047 \\
\hline
\text{log(leakage)} & = \beta_{total} & = 0.375
\end{array}
$$

The leakage estimate for this particular building is then $10^{0.375}$, or 2.37 L/sec-m^2. Note that positive beta values indicate an increase in building leakage while negative beta values indicate a tighter building. Relative differences between beta values translate to differences in building leakage. A 0.01 difference between two beta values, for example, indicates at difference of a factor of 1.02 difference in building leakage ($10^{0.01}$).

1.0 Computer code

We implemented the statistical model using the package BUGS, which stands for Bayes Using Gibbs Sampling. Specifically, we used WinBUGS version 1.4. The computer code to fit the model is given below.

```
model{
for (i in 1:Nbuilding) {
muY[i]<-betaCtry[CN[i]]          +betaBldg[BuildingType[i]]          +
betaConst[ConstType[i]] +betaCombo[Combo[i]]
y[i] ~ dnorm(muY[i], TauY[Combo[i]])
}
for (j in 1:Ncountry) {
etaCtry[j] ~ dnorm(0, tau.etaCtry)
betaCtry[j] <- muCtry + xiCtry*etaCtry[j]
}
for (k in 1:Nbldgtype) {
etaBldg[k] ~ dnorm(0, tau.etaBldg)
betaBldg[k] <- xiBldg*etaBldg[k]
}
for (m in 1:Nconsttype) {
etaConst[m] ~ dnorm(0, tau.etaConst)
betaConst[m] <- xiConst*etaConst[m]
}
for (n in 1:Ncombo) {
etaCombo[n] ~ dnorm(0, tau.etaCombo)
betaCombo[n] <- xiCombo*etaCombo[n]
}
for (n in 1:Ncombo) {
TauY[n] ~ dgamma(a1, a2)
}
```

```
a1 ~ dunif(0, 100)
a2 ~ dunif(0, 100)
xiCtry ~ dnorm(0, tau.xiCtry)
tau.xiCtry <- pow(prior.scale, -2)
tau.etaCtry ~ dgamma(.5, .5)
sigmaCtry <- abs(xiCtry)/sqrt(tau.etaCtry)
muCtry ~ dnorm (0.0, 1.0E-2)
xiBldg ~ dnorm(0, tau.xiBldg)
tau.xiBldg <- pow(prior.scale, -2)
tau.etaBldg ~ dgamma(.5, .5)
sigmaBldg <- abs(xiBldg)/sqrt(tau.etaBldg)
xiConst ~ dnorm(0, tau.xiConst)
tau.xiConst <- pow(prior.scale, -2)
tau.etaConst ~ dgamma(.5, .5)
sigmaConst <- abs(xiConst)/sqrt(tau.etaConst)
xiCombo ~ dnorm(0, tau.xiCombo)
tau.xiCombo <- pow(prior.scale, -2)
tau.etaCombo ~ dgamma(.5, .5)
sigmaCombo <- abs(xiCombo)/sqrt(tau.etaCombo)
}
```

2.0 Parameter estimates

The following table summarizes the parameter estimates and uncertainties for every parameter. Separate coefficient estimates (beta values) are given for each country effect, each building type and activity effect, each “combination” effect (capturing between-building-category variation that is not captured by an additive building type effect plus an additive activity effect) and for footprint and height effects.

Country	Coefficient Name	Mean	Std. Error	2.50%	25%	Median	75%	97.50%
US	betaCtry[1]	0.445	3.220	-7.350	0.024	0.575	1.029	7.474
Canada	betaCtry[2]	0.235	3.221	-7.584	-0.191	0.360	0.826	7.262
Sweden	betaCtry[3]	0.369	3.223	-7.440	-0.063	0.493	0.975	7.403
England	betaCtry[4]	0.609	3.221	-7.183	0.184	0.735	1.209	7.635
France	betaCtry[5]	0.406	3.221	-7.403	-0.017	0.535	1.000	7.432
Between Country Variability	**Variable Name**	**Mean**	**Std. Error**	**2.50%**	**25%**	**Median**	**75%**	**97.50%**
	sigmaCtry	0.247	0.199	0.057	0.139	0.200	0.294	0.710

BuildingType	Coefficient Name	Mean	Std. Error	2.50%	25%	Median	75%	97.50%
Education	betaBldg[1]	-0.080	0.083	-0.259	-0.132	-0.073	-0.020	0.064
Supermarket	betaBldg[2]	0.058	0.112	-0.151	-0.012	0.047	0.126	0.303
Mall	betaBldg[3]	0.093	0.147	-0.152	-0.003	0.069	0.174	0.437
Office	betaBldg[4]	-0.016	0.080	-0.180	-0.064	-0.013	0.032	0.143
Warehouse	betaBldg[5]	0.153	0.110	-0.027	0.070	0.147	0.226	0.384
SmallRetail	betaBldg[6]	-0.004	0.090	-0.190	-0.057	-0.002	0.052	0.176
StripMall	betaBldg[7]	0.143	0.122	-0.055	0.049	0.133	0.222	0.404
HealthCare	betaBldg[8]	0.008	0.094	-0.183	-0.048	0.006	0.064	0.197
PublicAssembly	betaBldg[9]	-0.113	0.100	-0.329	-0.178	-0.105	-0.039	0.052
Recreational	betaBldg[10]	-0.045	0.096	-0.254	-0.103	-0.036	0.015	0.134
Restaurant	betaBldg[11]	-0.040	0.103	-0.262	-0.101	-0.031	0.022	0.153
Lodging	betaBldg[12]	-0.026	0.101	-0.241	-0.085	-0.019	0.035	0.170
n/a	betaBldg[13]	-0.120	0.123	-0.394	-0.197	-0.105	-0.027	0.080
Between Building Type Variability	**Variable Name**	**Mean**	**Std. Error**	**2.50%**	**25%**	**Median**	**75%**	**97.50%**
	sigmaBldg	0.139	0.069	0.018	0.093	0.134	0.178	0.292

ConstructionType	Coefficient Name	Mean	Std. Error	2.50%	25%	Median	75%	97.50%
Masonry	betaConst[1]	-0.008	0.054	-0.127	-0.032	-0.003	0.016	0.100
FrameMasonry	betaConst[2]	0.035	0.079	-0.088	-0.007	0.014	0.065	0.239
ConcretePanel	betaConst[3]	-0.038	0.073	-0.223	-0.069	-0.018	0.004	0.074
MetalFrame	betaConst[4]	0.004	0.058	-0.117	-0.022	0.001	0.029	0.129
Curtainwall	betaConst[5]	-0.009	0.082	-0.204	-0.036	-0.002	0.024	0.155
Manufactured	betaConst[6]	-0.008	0.075	-0.181	-0.036	-0.002	0.023	0.143
WoodFrame	betaConst[7]	0.054	0.080	-0.051	0.000	0.030	0.090	0.257
n/a	betaConst[8]	-0.027	0.065	-0.186	-0.056	-0.013	0.007	0.083
Between Construction Type Variability	**Variable Name**	**Mean**	**Std. Error**	**2.50%**	**25%**	**Median**	**75%**	**97.50%**
	sigmaConst	0.073	0.064	0.003	0.027	0.057	0.102	0.234

Footprint	Coefficient Name	Mean	Std. Error	2.50%	25%	Median	75%	97.50%
<1000m^2	betaFP[1]	0.210	3.218	-6.805	-0.360	0.080	0.617	8.018
>1000m^2	betaFP[2]	0.046	3.218	-6.982	-0.527	-0.076	0.450	7.863
Between Footprint Variability	**Variable Name**	**Mean**	**Std. Error**	**2.50%**	**25%**	**Median**	**75%**	**97.50%**
	sigmaFP	4.017	7.948	0.075	0.350	1.230	4.279	24.120

Stories	Coefficient Name	Mean	Std. Error	2.50%	25%	Median	75%	97.50%
1	betaFN[1]	0.019	0.090	-0.093	-0.006	0.008	0.040	0.172
2to3	betaFN[2]	0.001	0.089	-0.125	-0.020	0.000	0.020	0.140
4to5	betaFN[3]	-0.018	0.094	-0.186	-0.039	-0.006	0.010	0.106
6orMore	betaFN[4]	-0.002	0.092	-0.146	-0.024	0.000	0.020	0.141

Between Story Variability	Variable Name	Mean	Std. Error	2.50%	25%	Median	75%	97.50%
	sigmaFN	0.078	0.158	0.002	0.019	0.044	0.088	0.349

Country	Building Type	Const Type	Combo	Data Points	Coefficient Name	Mean	Std. Error	2.50%	25%	Median	75%	97.50%
U.S	Education	Mansonry	USEduMas	39	betaCombo[1]	-0.047	0.083	-0.209	-0.103	-0.048	0.007	0.120
U.S	Education	Manufactured	USEduManuf	1	betaCombo[2]	-0.050	0.140	-0.331	-0.140	-0.048	0.042	0.223
U.S	Office	Mansony	USOffMas	9	betaCombo[3]	-0.150	0.102	-0.355	-0.217	-0.148	-0.081	0.046
U.S	Office	Tilt-up	USOffTilt	5	betaCombo[4]	0.065	0.114	-0.157	-0.012	0.063	0.140	0.295
U.S	Office	Metal	USOffMet	1	betaCombo[5]	-0.096	0.142	-0.384	-0.188	-0.093	-0.001	0.177
U.S	Office	Manufactured	USOffManuf	4	betaCombo[6]	0.014	0.116	-0.215	-0.062	0.014	0.090	0.244
U.S	Warehouse	Metal	USWareMet	1	betaCombo[7]	0.049	0.141	-0.224	-0.045	0.046	0.140	0.338
U.S	Small Retail	Masonry	USSmlRetMas	10	betaCombo[8]	-0.049	0.106	-0.262	-0.119	-0.049	0.021	0.158
U.S	Small Retail	Frame/Masonry	USSmlRetFrmMas	1	betaCombo[9]	0.099	0.144	-0.177	0.002	0.095	0.192	0.393
U.S	Small Retail	Metal	USSmlRetMet	2	betaCombo[10]	0.076	0.126	-0.169	-0.008	0.075	0.158	0.328
U.S	Small Retail	Frame	USSmlRetFrm	1	betaCombo[11]	0.164	0.155	-0.127	0.058	0.158	0.264	0.483
U.S	Strip Mall	Frame/Masonry	USStrpMllFrmMas	12	betaCombo[12]	0.129	0.127	-0.116	0.042	0.128	0.216	0.378
U.S	Strip Mall	Frame	USStrpMllFrm	4	betaCombo[13]	0.103	0.131	-0.147	0.014	0.099	0.190	0.369
U.S	Health Care	Masonry	USHealthMas	8	betaCombo[14]	-0.041	0.104	-0.249	-0.109	-0.040	0.028	0.162
U.S	Public	Masonry	USPubMas	8	betaCombo[15]	-0.027	0.110	-0.245	-0.100	-0.026	0.046	0.188
U.S	Public	Frame/Masonry	USPubFrmMas	1	betaCombo[16]	-0.085	0.143	-0.379	-0.178	-0.082	0.010	0.190
U.S	Rec	Masonry	USRecMas	14	betaCombo[17]	-0.080	0.101	-0.279	-0.147	-0.080	-0.014	0.118
U.S	Resturant	Masonry	USRestMas	4	betaCombo[18]	-0.047	0.118	-0.283	-0.125	-0.046	0.031	0.184
U.S	Resturant	Frame/Masonry	USRestFrmMas	1	betaCombo[19]	0.014	0.140	-0.261	-0.078	0.013	0.105	0.291
U.S	Resturant	Frame	USRestFrm	2	betaCombo[20]	-0.026	0.129	-0.286	-0.110	-0.025	0.059	0.226
U.S	Lodging	Masonry	USLodgMas	3	betaCombo[21]	-0.009	0.120	-0.248	-0.087	-0.008	0.070	0.228
Sweden	Warehouse	Masonry	SwedWareMas	5	betaCombo[22]	0.242	0.123	0.008	0.158	0.239	0.322	0.493
Sweden	Warehouse	Tilt-up	SwedWareTilt	6	betaCombo[23]	-0.351	0.137	-0.623	-0.442	-0.350	-0.260	-0.086
Sweden	Warehouse	Metal	SwedWareMet	12	betaCombo[24]	0.074	0.118	-0.153	-0.005	0.071	0.151	0.313
France	Education	Masonry	FranEduMas	2	betaCombo[25]	-0.008	0.125	-0.257	-0.090	-0.007	0.074	0.237
France	Education	Metal	FranEduMet	1	betaCombo[26]	-0.132	0.149	-0.437	-0.227	-0.128	-0.031	0.150
France	Education	Frame	FranEduFrm	1	betaCombo[27]	-0.022	0.140	-0.301	-0.113	-0.021	0.070	0.253
France	Office	Masonry	FranOffMas	1	betaCombo[28]	0.081	0.141	-0.192	-0.013	0.079	0.173	0.367
France	Office	Frame	FranOffFrm	1	betaCombo[29]	0.036	0.140	-0.238	-0.056	0.035	0.127	0.316
France	Warehouse	Metal	FranWareMet	4	betaCombo[30]	0.051	0.127	-0.193	-0.034	0.048	0.134	0.308
France	Rec	Masonry	FranRecMas	1	betaCombo[31]	0.038	0.139	-0.238	-0.053	0.037	0.129	0.315
France	Rec	Framce	FranRecFrm	1	betaCombo[32]	-0.019	0.141	-0.300	-0.110	-0.017	0.073	0.257
France	Lodging	Masonry	FranLodgMas	2	betaCombo[33]	-0.055	0.129	-0.314	-0.139	-0.053	0.031	0.198
France	Lodging	Frame	FranLodgFram	2	betaCombo[34]	0.021	0.131	-0.236	-0.065	0.021	0.107	0.283
England	Office	Masonry	EngOffMas	10	betaCombo[35]	-0.159	0.110	-0.380	-0.232	-0.157	-0.086	0.052
England	Office	Tilt-up	EngOffTilt	4	betaCombo[36]	-0.003	0.122	-0.245	-0.083	-0.003	0.077	0.237
England	Office	Metal	EngOffMet	8	betaCombo[37]	0.121	0.114	-0.102	0.045	0.119	0.196	0.347
England	Warehouse	Masonry	EngWareMas	1	betaCombo[38]	-0.002	0.140	-0.277	-0.094	-0.003	0.089	0.279
England	Warehouse	Metal	EngWareMet	3	betaCombo[39]	0.139	0.131	-0.108	0.050	0.135	0.224	0.407
England	Warehouse	N/A	EngWareNA	3	betaCombo[40]	0.090	0.132	-0.160	0.001	0.086	0.175	0.361
Canada	Education	Masonry	CanEduMas	11	betaCombo[41]	0.051	0.109	-0.162	-0.020	0.051	0.123	0.266
Canada	Supermarket	Masonry	CanSupMas	7	betaCombo[42]	0.083	0.120	-0.151	0.004	0.083	0.163	0.321
Canada	Supermarket	Tilt-up	CanSupTilt	2	betaCombo[43]	0.008	0.134	-0.256	-0.080	0.007	0.095	0.274
Canada	Mall	Masonry	CanMallMas	1	betaCombo[44]	0.123	0.153	-0.167	0.020	0.117	0.221	0.440
Canada	Office	Tilt-up	CanOffTilt	4	betaCombo[45]	0.080	0.120	-0.155	0.000	0.080	0.159	0.317
Canada	Office	Curtainwall	CanOffCurtain	2	betaCombo[46]	-0.023	0.132	-0.287	-0.109	-0.022	0.063	0.236
Canada	Small Retail	N/A	CanSmlRetNA	4	betaCombo[47]	-0.277	0.136	-0.554	-0.368	-0.274	-0.183	-0.020
Canada	Rec	N/A	CanRecNA	2	betaCombo[48]	-0.158	0.150	-0.468	-0.254	-0.152	-0.057	0.123
Canada	N/A	N/A	CanNANA	2	betaCombo[49]	-0.056	0.136	-0.332	-0.145	-0.054	0.034	0.207
U.S	Education	Metal	USEduMet	3	betaCombo[50]	-0.049	0.118	-0.285	-0.127	-0.048	0.029	0.182
U.S	Education	N/A	USEduNA	14	betaCombo[51]	0.087	0.095	-0.094	0.024	0.085	0.148	0.281
U.S	Health Care	Metal	USHealthMet	2	betaCombo[52]	-0.031	0.125	-0.278	-0.113	-0.030	0.051	0.216
U.S	Health Care	Frame	USHealthFrm	1	betaCombo[53]	0.062	0.141	-0.212	-0.032	0.060	0.153	0.347
U.S	Health Care	N/A	USHealthNA	1	betaCombo[54]	0.042	0.139	-0.229	-0.050	0.040	0.132	0.322
U.S	Public	Metal	USPubMet	5	betaCombo[55]	-0.045	0.112	-0.267	-0.119	-0.044	0.030	0.175
U.S	Public	N/A	USPubNA	3	betaCombo[56]	0.106	0.121	-0.128	0.025	0.105	0.185	0.350
U.S	Rec	N/A	USRecNA	2	betaCombo[57]	-0.009	0.127	-0.261	-0.092	-0.009	0.075	0.242
U.S	N/A	Metal	USNAMet	1	betaCombo[58]	-0.122	0.150	-0.429	-0.218	-0.117	-0.021	0.159
U.S	N/A	N/A	USNANA	1	betaCombo[59]	-0.006	0.141	-0.285	-0.098	-0.005	0.087	0.272

Between Combo Variability	Variable Name	Mean	Std. Error	2.50%	25%	Median	75%	97.50%
	sigmaCombo	0.165	0.034	0.100	0.142	0.163	0.186	0.236

Appendix C

Commercial Building Data

APPENDIX C: COMMERCIAL BUILDING DATA

STUDY_ID 1
SOURCE CY Shaw and L Jones, "Air tightness and air infiltration of school buildings", ASHRAE Transactions, Vol 85, Part I, p.85-95
COUNTRY Canada
STUDY_YEAR 1979

DATA_TABLE

	FloorArea	Height	EnvelopeArea	Volume	ELA50	Year Built	Year Tested	Building Type	Const Type	Country	US State
						6.7					
	[m2]	[m]	[m2]	[m3]	[m3/s/m2]						
A	2694	4.3	1175	11495	0.0067	1970	1976	Education	Masonry	Canada	n/a
B	1858	4	1136	7361	0.00475	1971	1976	Education	Masonry	Canada	n/a
C	3771	3.4	1875	12644	0.0065	1965	1976	Education	Masonry	Canada	n/a
D	3493	3.8	1610	13307	0.009	1973	1976	Education	Masonry	Canada	n/a
E	3689	3.8	2102	14054	0.0056	1957	1976	Education	Masonry	Canada	n/a
F	3093	3.7	1256	11314	0.00483	1952	1976	Education	Masonry	Canada	n/a
G	5388	3.7	1967	19706	0.00567	1968	1976	Education	Masonry	Canada	n/a
H	5156	4	1613	20427	0.00425	1965	1976	Education	Masonry	Canada	n/a
I	2620	3.8	1241	9980	0.0086	1968	1976	Education	Masonry	Canada	n/a
J	3003	4	1365	11900	0.0067	1972	1976	Education	Masonry	Canada	n/a
K	3219	3.8	1815	12263	0.00467	1968	1976	Education	Masonry	Canada	n/a

STANDARDIZED_TABLE

	EntryID	FootprintArea	FloorArea	SurfaceArea	Volume	Nfloors	Height	Width	Length	DeltaP	Q
A	1	2694	2694	3869	11495	1	4.3	44.3	60.8	50	7.9
B	2	1858	1858	2994	7361	1	4	21.1	88.2	50	5.4
C	3	3771	3771	5646	12644	1	3.4	19.6	192.5	50	12.2
D	4	3493	3493	5103	13307	1	3.8	25.4	137.6	50	14.5
E	5	3689	3689	5791	14054	1	3.8	19.0	193.7	50	11.8
F	6	3093	3093	4349	11314	1	3.7	31.1	99.5	50	6.1
G	7	5388	5388	7355	19706	1	3.7	31.1	173.4	50	11.2
H	8	5156	5156	6769	20427	1	4	48.3	106.8	50	6.9
I	9	2620	2620	3861	9980	1	3.8	26.4	99.2	50	10.7
J	10	3003	3003	4368	11900	1	4	29.5	101.7	50	9.1
K	11	3219	3219	5034	12263	1	3.8	19.6	164.1	50	8.5

NOTES

(1) FloorArea = L*W*n
(2) EnvelopeArea = 2*H*(L+W)
Assuming all buildings are single-storey i.e. n = 1 (by inspection of H)
Solve for W using (1) and (2)
W^2 - (EnvelopeArea/2H)*W + FloorArea = 0
The aspect ratios of W to L look off… it is plausible that the reported H is slightly too low for this calculation
If I set: H = H*factor
Then I get slightly 'more reasonable' results
ELA50 is normalized by the 'exterior wall area', assumed that this includes the window area' because this seems to be the intention of the of authors in their Table 1

n	n_Flag	Year_Built	Year_Tested	Building_Type	Const_Typ	Country	US_State
0.60	M	1970	1976	1	1	Canada	n/a
0.64	M	1971	1976	1	1	Canada	n/a
0.78	M	1965	1976	1	1	Canada	n/a
0.62	M	1973	1976	1	1	Canada	n/a
0.62	M	1957	1976	1	1	Canada	n/a
0.63	M	1952	1976	1	1	Canada	n/a
0.87	M	1968	1976	1	1	Canada	n/a
0.72	M	1965	1976	1	1	Canada	n/a
0.57	M	1968	1976	1	1	Canada	n/a
0.70	M	1972	1976	1	1	Canada	n/a
0.77	M	1968	1976	1	1	Canada	n/a

STUDY_ID 2
SOURCE CY Shaw, "Air tightness: supermarkets and shopping malls", ASHRAE Journal, March 1981, p.44-46
COUNTRY Canada
STUDY_YEAR 1981
DATA_TABLE

	Height	Wall Area	Window Area	ELA50	Year Built	Year Tested	Building Type	Const Type	Country	US State
	[m]	[m2]	[m2]	[L/s/m2]						
BH	8.4	1489	99.3	6.5	1957	1979	supermarket	masonry	Canada	n/a
CK	8.4	1594	75.7	5.07	1963	1979	supermarket	masonry	Canada	n/a
HC	7.7	1770	55.3	15	1978	1979	supermarket	masonry	Canada	n/a
MD	8.4	1392	15	13.14	1977	1979	mall	masonry	Canada	n/a
MK	7.1	1250	76.7	8.57	1967	1979	supermarket	masonry	Canada	n/a
MS	4.3	960	119	12.86	1955	1979	supermarket	masonry	Canada	n/a
OD	7.5	2014	35.7	13.57	1979	1979	supermarket	concrete panel	Canada	n/a
PO	7.5	3677	0	5.57	1979	1979	supermarket	concrete panel	Canada	n/a
RM	5.5	772.5	67.6	4.5	1957	1979	supermarket	masonry	Canada	n/a
WG	5.5	1079	94.7	14.43	1954	1979	supermarket	masonry	Canada	n/a

STANDARDIZED_TABLE

	EntryID	FootprintArea	FloorArea	SurfaceArea	Volume	Nfloors	Height	Width	Length	DeltaP
BH	12	2145	2145	3634	18019	1	8.4	37.8	56.7	50
CK	13	2371	2371	3965	19914	1	8.4	39.8	59.6	50
HC	14	3372	3372	5142	25961	1	7.7	47.4	71.1	50
MD	15	1683	1683	3075	14140	1	8.4	33.5	50.3	50
MK	16	2095	2095	3345	14874	1	7.1	37.4	56.1	50
MS	17	3778	3778	4738	16245	1	4.3	50.2	75.3	50
OD	18	4481	4481	6495	33610	1	7.5	54.7	82.0	50
PO	19	14422	14422	18099	108163	1	7.5	98.1	147.1	50
RM	20	1400	1400	2172	7699	1	5.5	30.5	45.8	50
WG	21	2732	2732	3811	15028	1	5.5	42.7	64.0	50

NOTES

(1) EnvelopeArea = 2*H*(L+W)
Assuming an aspect ratio of 1.5, and that Wall area + Window area = Envelope area
W = (Wall + Window area)/2/H/2.5
Assumed that all buildings are 1-storey (seems reasonable for malls and supermarkets, but some 2-storey or bi-level are certainly plausible)
ELA50 is normalized by the 'exterior wall area', I assumed that this excludes the 'window area' because this seems to be the intention of the of authors in their Table 1

			Q	n	n_Flag	Year_Built	Year_Tested	Building_Type	Const_Type	Country
	Est. Width	Est. Length	9.7	0.57	M	1957	1979	2	1	Canada
BH	37.8	56.7	8.1	0.62	M	1963	1979	2	1	Canada
CK	39.8	59.6	26.6	0.72	M	1978	1979	2	1	Canada
HC	47.4	71.1	18.3	0.56	M	1977	1979	3	1	Canada
MD	33.5	50.3	10.7	0.72	M	1967	1979	2	1	Canada
MK	37.4	56.1	12.3	0.67	M	1955	1979	2	1	Canada
MS	50.2	75.3	27.3	0.66	M	1979	1979	2	3	Canada
OD	54.7	82.0	20.5	0.79	M	1979	1979	2	3	Canada
PO	98.1	147.1	3.5	0.69	M	1957	1979	2	1	Canada
RM	30.5	45.8	15.6	0.60	M	1954	1979	2	1	Canada
WG	42.7	64.0								

STUDY_ID 3
SOURCE CY Shaw, JT Reardon, "Changes in Airtightness Levels of Six Office Buildings", Airflow Performance of Building Envelopes, Components, and Systems, ASTM STP 1255.
COUNTRY Canada
STUDY_YEAR 1974

DATA_TABLE

	nfloors	Height/Floor [m]	Width [m]	Length [m]	Wall Area/Floor [m2]	Window [%]	Roof to Wall Area [%]	ELA50 [L/s/m2]	Year Built	Year Tested	Building Type	Const Type	Country	US State
A	9	4	51	64	908	38	31	4.85	1970	1970	office	concret panel	Canada	n/a
B	17	3.4	27	43	466	33	12	2.17	1964	1971	office	concret panel	Canada	n/a
D	20	3.2	23	28	328	26	8	2.54	1971	1971	office	curtainwall	Canada	n/a
E	21	3.2	25	48	466	35	11	1.81	1968	1974	office	curtainwall	Canada	n/a
F	16	3.2	25	56	525	52	15	1.73	1973	1974	office	concret panel	Canada	n/a
G	25	3.2	37	44	524	26	11	2.49	1974	1974	office	concret panel	Canada	n/a

STANDARDIZED_TABLE

	EntryID	Footprint Area	FloorArea	SurfaceArea	Volume	Nfloors	Height	Width	Length	DeltaP	Q	n	n_Flag	Year_Built	Year_Tested	Building_Type	Const_Type	Country	US_State
A	22	3264	29376	10705	117504	9	36	51	64	50	40	0.64	M	1970	1970	4	3	Canada	n/a
B	23	1161	19737	8873	67105.8	17	57.8	27	43	50	17	0.52	M	1964	1971	4	3	Canada	n/a
D	24	644	12880	7085	41216	20	64	23	28	50	17	0.51	M	1971	1971	4	5	Canada	n/a
E	25	1200	25200	10862	80640	21	67.2	25	48	50	18	0.80	M	1968	1974	4	5	Canada	n/a
F	26	1400	22400	9660	71680	16	51.2	25	56	50	15	0.76	M	1973	1974	4	3	Canada	n/a
G	27	1628	40700	14541	130240	25	80	37	44	50	33	0.71	M	1974	1974	4	3	Canada	n/a

NOTES
Assumed that: Height = nfloors*Height/Floor
Assumed that: Volume = L*W*H
Assumed that: Footprint Area = L*W
Assumed that: FloorArea = L*W*nfloors
Assumed that: SurfaceArea = Wall Area/Floor * nFloors + (1+Roof to Wall Area Ratio)
Assumed that ELA50 is normalized to Wall Area/Floor * nFloor

STUDY_ID 4
SOURCE RA Grot and AK Persily, "Pressureization testing of federal buildings", Measured Air Leakage of Buildings, ASTM STP 904, p. 151-183.
COUNTRY US
STUDY_YEAR 1986

DATA_TABLE

	Floor Area [m2]	Volume [m3]	nFloors	Q25 [Volume/h]	ELA25 [m3/h/m2]	SurfaceArea [m2]	Year Built	Year Tested	Building Type	Const Type	Country	US State
Anchorage	48470	174000	4	0.80	6.7	23000	1981	1986	office	concrete panel	U.S.	Alaska
Ann Arbor	5270	31700	4	0.86	4.1	6630	1981	1986	office	concrete panel	U.S.	Michigan
Columbia	21600	159000	15	0.67	6	13800	1981	1986	office	concrete panel	U.S.	South Carolina
Huron	6910	27500	4	0.45	1.9	6620	1981	1986	office	masony	U.S.	South Dakota
Norfolk	18570	60300	8	1.45	7.2	12100	1981	1986	office	concrete panel	U.S.	Virginia
Pittsfield	1860	8520	2	0.95	3.5	2300	1981	1986	office	masony	U.S.	Massachusetts
Springfield	14560	57700	5	1.43	9.2	8940	1981	1986	office	concrete panel	U.S.	Massachusetts

STANDARDIZED_TABLE

	EntryID	FootprintArea	FloorArea	SurfaceArea	Volume	Nfloors	Height	Width	Length	DeltaP	Q	n
Anchorage	28	11375	45500	23000	174000	4	15.3	81.8	139.1	25	42.8	0.61
Ann Arbor	29	1225	4900	6630	31700	4	25.9	28.6	42.9	25	7.6	0.67
Columbia	30	1647	24700	13800	159000	15	96.6	40.6	40.6	25	23.0	0.47
Huron	31	1605	6420	6620	27500	4	17.1	40.1	40.1	25	3.5	0.64
Norfolk	32	2162.5	17300	12100	60300	8	27.9	38.0	57.0	25	24.2	0.74
Pittsfield	33	865	1730	2300	8520	2	9.8	24.0	36.0	25	2.2	0.36
Springfield	34	2700	13500	8940	57700	5	21.4	47.4	56.9	25	22.8	2.09

n_Flag	Year_Built	Year_Tested	Building_Type	Const_Type	Country	US_State
M	1981	1986	4	3	U.S.	AK
M	1981	1986	4	3	U.S.	MI
M	1981	1986	4	3	U.S.	SC
M	1981	1986	4	1	U.S.	SD
M	1981	1986	4	3	U.S.	VA
M	1981	1986	4	1	U.S.	MA
M	1981	1986	4	3	U.S.	MA

NOTES
nFloors are estimated (at times averaged) according to the building schematic provided
Estimated FootprintArea = FloorArea / nFloors
(1) FloorArea = L*W*n
(2) Volume = H*W*L
Estimated Height = Volume / FloorArea * n
SurfaceArea is giving by T Brennan (Study #5)
Estimate aspect ratio from schematic (many buildings are irregular shaped, but X refers to best approximation of a rectangular building)
Estimated Width = SQRT (Volume / H / X)
Estimated Year Tested as year of journal publication
Estimated Year Built (paper write that all building were built in the last 10 years)
Estimated Construction Type from photographs

STUDY_ID 5
SOURCE T Brennan, et al. "Fan pressurization of school buildings", ASHRAE
COUNTRY US
STUDY_YEAR 1992

DATA_TABLE

	Surface Area [m2]	Floor Area [m2]	C [m3/h*Pa^n]	n	ACH25	Year Built	Year Tested	Building Type	Const Type	Country	US State
Albany	27872	22297	15459	0.7	2.2	n/a	1992	Educational	masonry	U.S.	n/a
Admin	5853	8194	2564	0.34	0.3	n/a	1992	Educational	masonry	U.S.	n/a
Argentine	794	688	533	0.63	1.33	n/a	1992	Educational	masonry	U.S.	n/a
BishopRyan	6875	5574	1602	0.82	1.3	n/a	1992	Educational	masonry	U.S.	n/a
CLC	3270	4645	449	0.75	0.35	n/a	1992	Educational	masonry	U.S.	n/a
GreenMtn	2027	2369	2732	0.46	1.39	n/a	1992	Educational	masonry	U.S.	n/a
GmMtnGym	1672	929	2232	0.52	2.12	n/a	1992	Educational	masonry	U.S.	n/a
Laurel	3468	1517	1828	0.44	1.08	n/a	1992	Educational	masonry	U.S.	n/a
MiddleSchool	9142	7172	9390	0.61	3.03	n/a	1992	Educational	masonry	U.S.	n/a
Spines	5704	4422	860	0.76	0.73	n/a	1992	Educational	masonry	U.S.	n/a
STamaGym	1301	650	1038	0.5	2.64	n/a	1992	Educational	masonry	U.S.	n/a
Russell	4181	3252	907	0.99	2.24	n/a	1992	Educational	masonry	U.S.	n/a
Velva	6875	5574	4372	0.63	1.94	n/a	1992	Educational	masonry	U.S.	n/a

STANDARDIZED_TABLE

	EntryID	FootprintArea	FloorArea	SurfaceArea	Volume	Nfloors	Height	Width	Length	DeltaP	Q
Albany	35	22297	22297	27872	66883	1.00	3.0	121.9	182.9	25	40.9
Admin	36	4097	8194	5853	25533	2.00	6.2	52.3	78.4	25	2.1
Argentine	37	344	688	794	3045	2.00	8.9	15.1	22.7	25	1.1
BishopRyan	38	5574	5574	6875	17260	1.00	3.1	61.0	91.4	25	6.2
CLC	39	2322.5	4645	3270	14343	2.00	6.2	39.3	59.0	25	1.4
GreenMtn	40	1184.5	2369	2027	8640	2.00	7.3	28.1	42.2	25	3.3
GmMtnGym	41	464.5	929	1672	5614	2.00	12.1	17.6	26.4	25	3.3
Laurel	42	1517	1517	3468	6977	1.00	4.6	31.8	47.7	25	2.1
MiddleSchool	43	7172	7172	9142	22078	1.00	3.1	69.1	103.7	25	18.6
Spines	44	4422	4422	5704	13602	1.00	3.1	54.3	81.4	25	2.8
STamaGym	45	650	650	1301	1966	1.00	3.0	20.8	31.2	25	1.4
Russell	46	3252	3252	4181	9802	1.00	3.0	46.6	69.8	25	6.1
Velva	47	5574	5574	6875	17123	1.00	3.1	61.0	91.4	25	9.2

n	n_Flag	Year_Built	Year_Tested	Building_Type	Const_Type	Country	US_State
0.7	M	n/a	1992	1	1	U.S.	n/a
0.34	M	n/a	1992	1	1	U.S.	n/a
0.63	M	n/a	1992	1	1	U.S.	n/a
0.82	M	n/a	1992	1	1	U.S.	n/a
0.75	M	n/a	1992	1	1	U.S.	n/a
0.46	M	n/a	1992	1	1	U.S.	n/a
0.52	M	n/a	1992	1	1	U.S.	n/a
0.44	M	n/a	1992	1	1	U.S.	n/a
0.61	M	n/a	1992	1	1	U.S.	n/a
0.76	M	n/a	1992	1	1	U.S.	n/a
0.5	M	n/a	1992	1	1	U.S.	n/a
0.99	M	n/a	1992	1	1	U.S.	n/a
0.63	M	n/a	1992	1	1	U.S.	n/a

NOTES

Estimated that ACH25 [h-1] = C [m3/h*Pa^n] * (25Pa)^n / Volume
Therefore, Volume = ACH25 / C*25^n
(1) V = L*W*H
(2) SurfaceArea = 2*H*(L+W) + L*W
(3) FloorArea = L*W*n
Estimate Height/Floors by: Volume / FloorArea
Seems like all school buildings are 1 story => H = Height/Floors
2*H*W^2 + (FA/n - SA)*W + 2*H*FA/n = 0
where FA = FloorArea, SA = SurfaceArea, and n = number of floors
BUT… I don't get reasonable aspect ratio this way.
Try another method. Let's just assume that X = 1.5 and see if W anc
Assumed Year Tested in same year and journal publication

STUDY_ID 6
SOURCE Leif I. Lundin, "Air leakage in industrial bulidings - description of equipment", Measured Air Leakage of Buildings,
COUNTRY Sweden ASTM STP 904, HR Trechsel and PL Lagus, Eds., ASTM, Philadelphia, 1986, p. 101-105
STUDY_YEAR 1986

DATA_TABLE

	FloorArea [m2]	EnvelopeArea [m2]	Volume [m3]	Mean ELA [m3/h/m2]	Year Built	Year Tested	Building Type	Const Type	Country	US State
1	4137	6796	36373	7.9	n/a	1986	warehouse	concrete panel	Sweden	n/a
2	6524	9876	61127	6	n/a	1986	warehouse	concrete panel	Sweden	n/a
3	4236	5809	31622	3	n/a	1986	warehouse	metal panel	Sweden	n/a
4	1840	3150		5.4	n/a	1986	warehouse	metal panel	Sweden	n/a
5	1265	2100	8535	4.3	n/a	1986	warehouse	metal panel	Sweden	n/a
6	1620	2650	10050	3.1	n/a	1986	warehouse	concrete panel	Sweden	n/a
7	1025	1960	6275	5	n/a	1986	warehouse	concrete panel	Sweden	n/a
8	1846	2950	12528	2.5	n/a	1986	warehouse	concrete panel	Sweden	n/a
9	4140	6804	29975	2.1	n/a	1986	warehouse	concrete panel	Sweden	n/a

STANDARDIZED_TABLE

	EntryID	FootprintArea	FloorArea	SurfaceArea	Volume	Nfloors	Height	Width	Length	DeltaP
1	48	4609	4137	6796	36373	0.9	7.9	55.4	83.1	50
2	49	6864	6524	9876	61127	1.0	8.9	67.6	101.5	50
3	50	3681	4236	5809	31622	1.2	8.6	49.5	74.3	50
4	51	1840	1840	3150	13764	1.0	7.5	35.0	52.5	50
5	52	996	1265	2100	8535	1.3	8.6	25.8	38.6	50
6	53	1635	1620	2650	10050	1.0	6.1	33.0	49.5	50
7	54	1229	1025	1960	6275	0.8	5.1	28.6	42.9	50
8	55	1715	1846	2950	12528	1.1	7.3	33.8	50.7	50
9	56	5089	4140	6804	29975	0.8	5.9	58.2	87.4	50

Q	n	n_Flag	Year_Built	Year_Tested	Building_Type	Const_Type	Country
14.9	0.65	A	n/a	1986	5	3	Sweden
16.5	0.65	A	n/a	1986	5	3	Sweden
4.8	0.65	A	n/a	1986	5	5	Sweden
4.7	0.65	A	n/a	1986	5	5	Sweden
2.5	0.65	A	n/a	1986	5	5	Sweden
2.3	0.65	A	n/a	1986	5	3	Sweden
2.7	0.65	A	n/a	1986	5	3	Sweden
2.0	0.65	A	n/a	1986	5	3	Sweden
4.0	0.65	A	n/a	1986	5	3	Sweden

NOTES

Year Tested assumed ot by date of journal publication

(1) FloorArea = L*W*n

(2) EnvelopeArea = L*W + 2*H*(L+W)

(3) Volume = H*L*W

Assuming an aspect ratio of x = 1.5, i.e. L = 1.5*W

Solve for W using (2) and (3)

1.5*(W^3) - EnvelopeArea*W + 10/3*Volume :

Use 3Roots.R to solve this cubic equation to get W (1st root used (2nd root is -ve, and 3rd root too small (i.e. H too large: can't be 10 storey?))

Setting L = 1.5*W, find H by (3)

Use (1) to find number of storey n

STUDY_ID 7
SOURCE IN Potter, TJ Jones, WB Booth, "Air leakage of office buildings", Technical Note TN 8/95, BSRIA.
COUNTRY UK
STUDY_YEAR 1995

DATA_TABLE

	EnvelopeArea [m2]	FloorArea [m2]	Height [m]	Volume [m3]	nFloors	Q50 [m3/s]	n	Year Built	Year Tested	Building Type	Const Type	Country	US State
1	881.5	616	6.1	1951	2	2.47	0.61	1970	1995	office	concrete panels	England	n/a
2	5131	2972	8.5	14109	2	16.78	0.59	1900	1995	office	masonry	England	n/a
3	8932	12474	18.9	39149	5.5	29.94	0.52	1991	1995	office	masonry	England	n/a
4	4457	2476.5	7	14855	1.5	37.38	0.52	1985	1995	office	metal frame	England	n/a
5	4508	6666	14.5	16571	6	18.89	0.6	1963	1995	office	concrete panels	England	n/a
6	2689	3093	10.3	10590	3	17.63	0.48	1991	1995	office	metal frame	England	n/a
7	3328	4884	20	15360	6	37.06	0.52	1986	1995	office	metal frame	England	n/a
8	4783	6875	18.3	21008	5	15.94	0.53	1989	1995	office	metal frame	England	n/a
9	8810	6174	11.4	44335	2	47.09	0.61	1991	1995	office	metal frame	England	n/a
10	2786	1047	10.1	10357		13.38	0.54	1990	1995	office	metal frame	England	n/a
11	5504	5727.5	13.6	20379	2.5	49.89	0.67	1992	1995	office	metal frame	England	n/a
12	4724	4632.5	10	17577	2.5	48.98	0.49	1992	1995	office	metal frame	England	n/a

STANDARDIZED_TABLE

	EntryID	FootprintArea	FloorArea	SurfaceArea	Volume	Nfloors	Height	Width	Length	DeltaP	Q	n	n_Flag	Year_Built	Year_Tested	Building_Type	Const_Type	Country	US_State
1	57	308	616	881.5	1951	2	6.1	14.6	21.9	50	2.47	0.61	M	1970	1995	4	3	England	n/a
2	58	1486	2972	5131	14109	2	8.5	33.3	49.9	50	16.78	0.59	M	1900	1995	4	1	England	n/a
3	59	2268	12474	8932	39149	5.5	18.9	37.2	55.7	50	29.94	0.52	M	1991	1995	4	1	England	n/a
4	60	1651	2476.5	4457	14855	1.5	7	37.6	56.4	50	37.38	0.52	M	1985	1995	4	4	England	n/a
5	61	1111	6666	4508	16571	6	14.5	27.6	41.4	50	18.89	0.6	M	1963	1995	4	3	England	n/a
6	62	1031	3093	2689	10590	3	10.3	26.2	39.3	50	17.63	0.48	M	1991	1995	4	4	England	n/a
7	63	814	4884	3328	15360	6	20	22.6	33.9	50	37.06	0.52	M	1986	1995	4	4	England	n/a
8	64	1375	6875	4783	21008	5	18.3	27.7	41.5	50	15.94	0.53	M	1989	1995	4	4	England	n/a
9	65	3087	6174	8810	44335	2	11.4	50.9	76.4	50	47.09	0.61	M	1991	1995	4	4	England	n/a
10	66	349	1047	2786	10357	3	10.1	26.1	39.2	50	13.38	0.54	M	1990	1995	4	4	England	n/a
11	67	2291	5727.5	5504	20379	2.5	13.6	31.6	47.4	50	49.89	0.67	M	1992	1995	4	4	England	n/a
12	68	1853	4632.5	4724	17577	2.5	10	34.2	51.3	50	48.98	0.49	M	1992	1995	4	4	England	n/a

NOTES

(1) Envelope Area = 2*H*(L+W) + L*W
(2) Floor Area = n*L*W
(3) Volume = H*L*W

It seems like the 'EnvelopeArea' reported include roof.
Assuming that X = 1.5,
"Victorian" construction date assumed to be 1900
"mid-1990s" testing date assumed to be 1995

Building #10 has no number of storey.
Assumed it is a 3-storey building (it has height similar to #6, #9, #12)

STUDY_ID 8
SOURCE JB Cummings, CR Withers, N Moyer, P Fairey, B McKendry, "Uncontrolled air flow in non-residential buildings", Florida Solar Energy Center
COUNTRY UK
STUDY_YEAR 1996

28.31684659
33
171.0833333

DATA_TABLE

	Floor Area	SurfaceArea	Volume	nFloors	Q50	n	Year Built	Year Tested	Building Type	Const Type	Country	US State
	[ft2]	[ft2]	[ft3]		[ft3/min]							
1	5404	8124	59444	1	1980	0.67	1965	1996	office	masonry	U.S.	Florida
2	5000	8600	90000	1	10265	0.54	1965	1996	recreational	masonry	U.S.	Florida
3	2754	4433	24786	1	8826	0.59	1992	1996	health care	masonry	U.S.	Florida
4	10538	12824	217120	2	6056	0.58	1970	1996	public assembly	frame/masonry	U.S.	Florida
5	3384	5830	33840	1	9618	0.62	1959	1996	office	masonry	U.S.	Florida
6	12716	12931	152592	2	6193	0.6	1961	1996	office	masonry	U.S.	Florida
7	16875	23375	236250	1	27583	0.58	1968	1996	office	masonry	U.S.	Florida
8	880	2104	7920	1	3926	0.59	1981	1996	strip mall	frame/masonry	U.S.	Florida
9	1512	2923	12852	1	3265	0.34	1959	1996	health care	masonry	U.S.	Florida
10	6120	9882	102510	1	11195	0.5	1986	1996	office	masonry	U.S.	Florida
11	1795	3241	15258	1	7472	0.65	1960	1996	small retail	metal/masonry	U.S.	Florida
12	16713	22953	306649	1	22383	0.65	1987	1996	public assembly	masonry	U.S.	Florida
13	2592	4651	28940	1	12161	0.7	1970	1996	educational	masonry	U.S.	Florida
14	1680	3264	14835	1	2051	0.6	1990	1996	educational	manufactured	U.S.	Florida
15	2092	4540	25104	1	4371	0.49	1986	1996	health care	masonry	U.S.	Florida
16	4920	7618	46740	1	4898	0.52	1988	1996	office	Manufactured	U.S.	Florida
17	16700	22337	219529	1	18607	0.67	1975	1996	educational	masonry	U.S.	Florida
18	22461	32304	293710	2	17521	0.65	1986	1996	recreational	masonry	U.S.	Florida
19	1942	3542	15536	1	4137	0.54	1975	1996	restaurant	frame/masonry	U.S.	Florida
20	2952	5664	35424	1	3296	0.59	1969	1996	public assembly	masonry	U.S.	Florida
21	2560	4962	21760	1	9005	0.65	1987	1996	strip mall	frame	U.S.	Florida
22	3503	5802	49042	1	2164	0.6	1994	1996	restaurant	masonry	U.S.	Florida
23	3060	5613	35190	1	11845	0.59	1984	1996	warehouse	metal	U.S.	Florida
24	8650	14084	123630	1	2565	0.62	1989	1996	public assembly	masonry	U.S.	Florida
25	2708	5055	24776	1	12987	0.69	1987	1996	small retail	masonry	U.S.	Florida
26	960	1920	13280	1	5714	0.59	1994	1996	strip mall	frame	U.S.	Florida
27	960	1920	13280	1	5667	0.6	1994	1996	strip mall	frame	U.S.	Florida
28	1920	3835	26560	1	7848	0.51	1994	1996	strip mall	frame	U.S.	Florida
29	5040	7344	75600	1	16727	0.74	1983	1996	office	manufactured	U.S.	Florida
30	3240	4995	24300	2	20385	0.48	1941	1996	small retail	frame	U.S.	Florida
31	2400	4600	22800	1	6651	0.6	1986	1996	restaurant	masonry	U.S.	Florida
32	4351	7034	43768	1	8426	0.56	1994	1996	restaurant	frame	U.S.	Florida
33	3161	5616	41093	1	6995	0.58	1994	1996	restaurant	masonry	U.S.	Florida
34	1796	3548	14368	1	6145	0.58	1931	1996	strip mall	frame/masonry	U.S.	Florida
35	3321	5564	53136	1	3689	0.64	1986	1996	restaurant	masonry	U.S.	Florida
36	16100	22590	177100	1	11993	0.66	1966	1996	small retail	masonry	U.S.	Florida
37	1845	3272	26174	1	2241	0.6	1972	1996	small retail	masonry	U.S.	Florida
38	3965	5972	44505	1	3056	0.63	1972	1996	small retail	masonry	U.S.	Florida
39	2142	4049	20992	1	5879	0.68	1946	1996	small retail	masonry	U.S.	Florida
40	2460	4700	24600	1	10646	0.55	1966	1996	strip mall	frame/masonry	U.S.	Florida
41	704	1904	7040	1	3394	0.62	1966	1996	strip mall	frame/masonry	U.S.	Florida
42	6358	9038	92191	1	20201	0.82	1966	1996	strip mall	frame/masonry	U.S.	Florida
43	2108	4988	30566	1	15625	0.62	1966	1996	strip mall	frame/masonry	U.S.	Florida
44	1328	2883	10491	1	7560	0.7	1966	1996	strip mall	frame/masonry	U.S.	Florida
45	2550	4824	25500	1	9133	0.66	1966	1996	strip mall	frame/masonry	U.S.	Florida
46	3735	6285	54158	1	32886	0.98	1966	1996	strip mall	frame/masonry	U.S.	Florida
47	972	2602	9720	1	5012	0.82	1966	1996	strip mall	frame/masonry	U.S.	Florida
48	1322	2873	12425	1			1966	1996	strip mall	frame/masonry	U.S.	Florida
49	990	2610	9900	1	3504	0.57	1966	1996	strip mall	frame/masonry	U.S.	Florida
50	990	1620	9900	1	5108	0.58	1966	1996	strip mall	frame/masonry	U.S.	Florida
51	5428	9388	56389	1	9404	0.62	1951	1996	office	masonry	U.S.	Florida
52	1800	3621	21150	1	1943	0.62	1964	1996	office	masonry	U.S.	Florida
53	3872	6704	41308	1	3545	0.66	1986	1996	office	metal	U.S.	Florida
54	2635	4363	21080	1	7673	0.76	1976	1996	small retail	masonry	U.S.	Florida
55	10000	15635	115000	1	20346	0.6	1978	1996	small retail	metal	U.S.	Florida
56	12360	18684	206880	1	15825	0.59	1983	1996	small retail	metal	U.S.	Florida
57	7052	11507	74270	2	26544	0.48	1982	1996	recreational	masonry	U.S.	Florida
58	4656	8136	55872	1	4002	0.62	1994	1996	small retail	masonry	U.S.	Florida
59	1584	3564	17424	1	5338	0.73	1973	1996	small retail	masonry	U.S.	Florida
60	840	1950	6300	1	1281	0.61	1985	1996	office	manufactured	U.S.	Florida
61	1320	2632	10560	1	3592	0.59	1983	1996	office	manufactured	U.S.	Florida
62	7854	12679	106029	1	10172	0.86	1963	1996	restaurant	frame	U.S.	Florida
63	6641	10973	79692	1	3407	0.46	1990	1996	public assembly	masonry	U.S.	Florida
64	10136	15104	111496	1	7063	0.65	1965	1996	educational	masonry	U.S.	Florida
65	2000	3800	30660	1	1735	0.52	1965	1996	educational	masonry	U.S.	Florida
66	5068	8650	55748	1	11882	0.53	1965	1996	educational	masonry	U.S.	Florida
67	15033	23055	184122	1	23309	0.45	1977	1996	lodging	masonry	U.S.	Florida
68	12750	12055	102000	2	11520	0.62	1977	1996	lodging	masonry	U.S.	Florida
69	4320	7094	41904	1	11746	0.62	1989	1996	small retail	masonry	U.S.	Florida
70	2520	4915	29484	1	836	0.65	1969	1996	small retail	masonry	U.S.	Florida

NOTES "year measured" assumed to be date of journal publication.

STUDY_ID 9
SOURCE IN Potter, TJ Jones, "Ventilation heat loss in factories and warehouses", Technical Note TN 7/82, BSRIA.
COUNTRY UK
STUDY_YEAR 1992

DATA_TABLE

	EnvelopeArea [m2]	FootprintArea [m2]	Height [m]	Volume [m3]	Q50 [m3/s]	n	Year Built	Year Tested	Building Type	Const Type	Country	US State
1	1262	645	6.74	3276	12.16	0.5	n/a	1992	warehouse	masonry	Sweden	n/a
1a	2351	1373	6.74	7033	19.94	0.48	n/a	1992	warehouse	masonry	Sweden	n/a
2	2449	1363	8.75	10686	16.78	0.67	n/a	1992	warehouse	metal panels	Sweden	n/a
3	2351	1319	8.75	10380	17.02	0.57	n/a	1992	warehouse	metal panels	Sweden	n/a
4	3734	1501	16	19513	26.75	0.61	n/a	1992	warehouse	metal panels	Sweden	n/a
5	6763	4617	6.6	30007	51.46	0.46	n/a	1992	warehouse	masonry	Sweden	n/a
6	3641	2364	6.6	15364	28.6	0.52	n/a	1992	warehouse	masonry	Sweden	n/a
7	1089	447	8.5	3467	13.61	0.65	n/a	1992	warehouse	metal panels	Sweden	n/a
8	1506	848	6.1	4909	34.47	0.46	n/a	1992	warehouse	metal panels	Sweden	n/a
9	2685	1747	6.8	10399	29.97	0.52	n/a	1992	warehouse	masonry	Sweden	n/a
10	1771	972	8	6787	16.73	0.58	n/a	1992	warehouse	metal panels	Sweden	n/a
10a	3235	2081	8	14569	29.57	0.57	n/a	1992	warehouse	metal panels	Sweden	n/a
11	757	318	7	2088	8.95	0.44	n/a	1992	warehouse	metal panels	Sweden	n/a
12	3471	1983	9.75	17599	26.64	0.59	n/a	1992	warehouse	metal panels	Sweden	n/a

STANDARDIZED_TABLE

	EntryID	FootprintArea	FloorArea	SurfaceArea	Volume	Nfloors	Height	Width	Length	DeltaP	Q	n
1	138	645	645	1262	3276	1	6.74	18.0	27.0	50	12.2	0.5
1a	139	1373	1373	2351	7033	1	6.74	26.4	39.6	50	19.9	0.48
2	140	1363	1363	2449	10686	1	8.75	28.5	42.8	50	16.8	0.67
3	141	1319	1319	2351	10380	1	8.75	28.1	42.2	50	17.0	0.57
4	142	1501	1501	3734	19513	1	16	28.5	42.8	50	26.8	0.61
5	143	4617	4617	6763	30007	1	6.6	55.1	82.6	50	51.5	0.46
6	144	2364	2364	3641	15364	1	6.6	39.4	59.1	50	28.6	0.52
7	145	447	447	1089	3467	1	8.5	16.5	24.7	50	13.6	0.65
8	146	848	848	1506	4909	1	6.1	23.2	34.7	50	34.5	0.46
9	147	1747	1747	2685	10399	1	6.8	31.9	47.9	50	30.0	0.52
10	148	972	972	1771	6787	1	8	23.8	35.7	50	16.7	0.58
10a	149	2081	2081	3235	14569	1	8	34.8	52.3	50	29.6	0.57
11	150	318	318	757	2088	1	7	14.1	21.2	50	9.0	0.44
12	151	1983	1983	3471	17599	1	9.75	34.7	52.0	50	26.6	0.59

n_Flag	Year_Built	Year_Tested	Building_Type	Const_Type	Country	US_State
M	n/a	1992	5	1	Sweden	n/a
M	n/a	1992	5	1	Sweden	n/a
M	n/a	1992	5	4	Sweden	n/a
M	n/a	1992	5	4	Sweden	n/a
M	n/a	1992	5	4	Sweden	n/a
M	n/a	1992	5	1	Sweden	n/a
M	n/a	1992	5	1	Sweden	n/a
M	n/a	1992	5	4	Sweden	n/a
M	n/a	1992	5	4	Sweden	n/a
M	n/a	1992	5	1	Sweden	n/a
M	n/a	1992	5	4	Sweden	n/a
M	n/a	1992	5	4	Sweden	n/a
M	n/a	1992	5	4	Sweden	n/a
M	n/a	1992	5	4	Sweden	n/a

NOTES
Year Tested assumed ot by date of journal publication
Year Built is not indicated in paper.
Are all these warehouses and factories 1-storey? We'll just assume so.
If we assume that X = 1.5, we get pretty close to the reported surface area =)

STUDY_ID 10
SOURCE A Litvak, D Boze, M Kilberger, "Airtightness of 12 non residential large buildings results from field measurement studies", 22nd AIVC conference, 11-14 Sept 2001, Bath, UK.
COUNTRY France
STUDY_YEAR 2001

DATA_TABLE

	Envelope Area [m2]	Volume [m3]	ELA4 [m3/h/m2]	n	Year Built	Year Tested	Building Type	Const Type	Country	US State
Foyer CAT	800	2695	7	0.53	1998	2001	lodging	wood frame	France	n/a
Etap Hotel	520	660	2.75	0.57	1998	2001	lodging	masonry	France	n/a
Hotel Parada	717	2871	2.05	0.64	1998	2001	lodging	masonry	France	n/a
Etang du puits	682	1115	1.9	0.74	1998	2001	lodging	wood frame	France	n/a
Ecole	1736	4287	1.8	0.625	1998	2001	educational	wood frame	France	n/a
College Joilot-C	1602	4862	2.05	0.69	1998	2001	educational	masonry	France	n/a
Ecole	2045	4563	1.25	0.77	1998	2001	educational	masonry	France	n/a
Lycee Millitaire	2473	7426	0.8	0.58	1998	2001	educational	metal frame	France	n/a
ONF	878	1809	4.3	0.64	1998	2001	office	wood frame	France	n/a
CMR	685	1688	6.15	0.55	1998	2001	office	masonry	France	n/a
Salle municipal	814	1702	3.2	0.58	1998	2001	recreational	wood frame	France	n/a
Cosec	1245	3306	4	0.6	1998	2001	recreational	masonry	France	n/a

STANDARDIZED_TABLE

	EntryID	FootprintArea	FloorArea	SurfaceArea	Volume	Nfloors	Height	Width	Length	DeltaP	Q	n	n_Flag	Year_Built	Year_Tested	Building_Type	Const_Type	Country
Foyer CAT	152	312	623	800	2695	2	8.6	14.4	21.6	4	1.56	0.53	M	1998	2001	12	7	France
Etap Hotel	153	382	382	520	660	1	2.5	16.0	23.9	4	0.40	0.57	M	1998	2001	12	1	France
Hotel Parada	154	325	650	717	2871	2	8.8	14.7	22.1	4	0.41	0.64	M	1998	2001	12	1	France
Etang du puits	155	473	473	682	1115	1	2.4	17.8	26.6	4	0.36	0.74	M	1998	2001	12	7	France
Ecole	156	1239	1239	1736	4287	1	3.5	28.7	43.1	4	0.87	0.625	M	1998	2001	1	7	France
ollege Joilot-Cu	157	962	962	1602	4862	1	5.1	25.3	38.0	4	0.91	0.69	M	1998	2001	1	1	France
Ecole	158	1576	1576	2045	4563	1	2.9	32.4	48.6	4	0.71	0.77	M	1998	2001	1	1	France
Lycee Millitaire	159	1748	1748	2473	7426	1	4.2	34.1	51.2	4	0.55	0.58	M	1998	2001	1	4	France
ONF	160	568	568	878	1809	1	3.2	19.5	29.2	4	1.05	0.64	M	1998	2001	4	7	France
CMR	161	242	484	685	1688	2	7.0	12.7	19.1	4	1.17	0.55	M	1998	2001	4	1	France
Salle municipale	162	505	505	814	1702	1	3.4	18.3	27.5	4	0.72	0.58	M	1998	2001	10	7	France
Cosec	163	753	753	1245	3306	1	4.4	22.4	33.6	4	1.38	0.6	M	1998	2001	10	1	France

NOTES
Paper states "buildings measured between 11/00 and 06/01." Year Tested assumed to be 2001
Paper states "building <5 years old." Year Built assumed to be 1998

(1) Envelope Area = 2*H*(L+W) + L*W
(2) Volume = H*L*W
If we assume that X = 1.5
(1) and (2) reduce to:
1.5*(W^3) - EnvelopeArea*W + 10/3*Volume = 0

STUDY_ID 11
SOURCE E. Flury et al. "Theoretical and field study of air change in industrial buildings," 19th AIVC Conference, Oslo, Norway, 28-30 September, 1998.
COUNTRY France
STUDY_YEAR 1998

DATA_TABLE

Building	Area [m2]	Volume [m3]	Q50 (inc. P) [m3/h]	Q50 (dec. P) [m3/h]	Average Q50	n (inc. P)	n (dec. P)	Average n	Year Built	Year Tested	Building Type	Const Type	Country	US State
1	695	2967	30227	32378	31302.5	0.55	0.65	0.6	1992	1997	warehouse	metal panel	France	n/a
3	671	3086	27637	26860	27248.5	0.68	0.68	0.68	1981	1997	warehouse	metal panel	France	n/a
4	1347	6957	23705	23837	23771	0.79	0.79	0.79	1988	1997	warehouse	metal panel	France	n/a
5	558	2500	44930	46723	45826.5	0.81	0.82	0.815	1990	1997	warehouse	metal panel	France	n/a

STANDARDIZED_TABLE

	EntryID	FootprintArea	FloorArea	SurfaceArea	Volume	Nfloors	Height	Width	Length	DeltaP	Q	n	n_Flag	Year_Built
1	164	695	695	1154	2967	1	4.3	21.5	32.3	50	8.70	0.6	M	1992
3	165	671	671	1157	3086	1	4.6	21.2	31.7	50	7.57	0.68	M	1981
4	166	1347	1347	2121	6957	1	5.2	30.0	44.9	50	6.60	0.79	M	1988
5	167	558	558	990	2500	1	4.5	19.3	28.9	50	12.73	0.815	M	1990

Year_Tested	Building_Type	Const_Type	Country	US_State
1997	5	4	France	n/a
1997	5	4	France	n/a
1997	5	4	France	n/a
1997	5	4	France	n/a

NOTES
We assumed that by 'Area', the authors mean Floor Area
Height = Volume / FloorArea
Assumed that all buildings are 1 storey
To find W and L, we assumed an aspect ratio of 1.5
Assumed that SufaceArea = 2*H*(L+W) + L*W
Year Tested assumed ot by date of journal publication
Paper identifies buildings as "industrial." Building appear to be single story from volume/area ratio. Building Type assumed to be Warehouse.
Paper identifies buildings to have a "metallic structure." Construction Type assumed to be Metal Panel.

STUDY_ID 12
SOURCE MDAES Perera, J Henderson, and BC Webb, "Predicting Envelope Air Leakage in Large Commercial Buildings Before Construction", 18th AIVC Conference, Athens, Greece, 23-26 September, 1997
COUNTRY UK
STUDY_YEAR 1997

DATA_TABLE

Building	Surface Area	Volume	**ELA25**	Year Built	Year Tested	Building Type	Const Type	Country	US State
	[m2]	[m3]	**[m3/h/m2]**						
1	1750	5315	5.5	1980	1997	office	masonry	England	n/a
2	3769	13749	5.3	1963	1997	office	masonry	England	n/a
3	8189	32479	5.5	1991	1997	office	masonry	England	n/a
4	2195	6254	11.8	1965	1997	office	masonry	England	n/a
5	1105	2516	6.7	1987	1997	office	masonry	England	n/a
6	2508	8651	9	1990	1997	office	masonry	England	n/a
7	829	2045	15.3	1990	1997	office	masonry	England	n/a
8	3056	8168	16.8	1971	1997	office	conrete panel	England	n/a
9	4726	14904	17.9	1986	1997	office	masonry	England	n/a
10	4394	14126	20.4	1985	1997	office	concrete panel	England	n/a

STANDARDIZED_TABLE

	EntryID	FootprintArea	FloorArea	SurfaceArea	Volume	Nfloors	Height	Width	Length	DeltaP	Q	n	n_Flag	Year_Built
1	168	#REF!	#REF!	1750	5315	3	7.4	12.0	60.0	25	3.2	0.6	M	1980
2	169	255	4583	3769	13749	18	53.9	13.0	19.6	25	5.5	0.65	A	1963
3	170	281	10826	8189	32479	39	115.5	13.7	20.5	25	12.5	0.65	A	1991
4	171	782	2345	2195	6254	3	8.0	10.2	76.9	25	7.2	0.51	M	1965
5	172	106	839	1105	2516	8	23.8	8.4	12.6	25	2.1	0.65	A	1987
6	173	243	2884	2508	8651	12	35.6	12.7	19.1	25	6.3	0.65	A	1990
7	174	152	682	829	2045	4	13.4	10.1	15.1	25	3.5	0.65	A	1990
8	175	130	2723	3056	8168	21	62.9	9.3	14.0	25	14.3	0.65	A	1971
9	176	179	4968	4726	14904	28	83.2	10.9	16.4	25	23.5	0.65	A	1986
10	177	188	4709	4394	14126	25	75.1	11.2	16.8	25	24.9	0.65	A	1985

Year_Teste	Building_Type	Const_Type	Country	US_State
1997	4	1	England	n/a
1997	4	1	England	n/a
1997	4	1	England	n/a
1997	4	1	England	n/a
1997	4	1	England	n/a
1997	4	1	England	n/a
1997	4	1	England	n/a
1997	4	3	England	n/a
1997	4	1	England	n/a
1997	4	3	England	n/a

NOTES

Year Tested assumed ot by date of journal publication

Details on building 1 and 4 are described in: MDAES Perera, RK Stephen, RG Tull, "Airtightness measurements of two UK office buildings", Air Change Rate and Airtightness in Buildings, ASTM STP 1067, MH Sherman, Ed., ASTM, Philadelphia, 1990, p 211-221.

For those without reported Q25, values are computed by ELA25 * Area

Building 4 has non-regular shape (T-shaped consists of a 2-storey block and a 4-storey block), but we assumed that it is rectangular when estimating W and L

For Building 4:

Assumed that H = 8 m (b/c 3-storey)

Get L and W to fit both the reported Volume and SurfaceArea

18*W^2 + (Volume/8 - SurfaceArea)*W + 2*Volume = 0

STUDY_ID 13
SOURCE MDAES Perera, RG Tull, "Envelope leakiness of large, naturally ventilated buildings", 10th AIVC Conference, Dipoli, Finland, 25-28 September, 1989.
COUNTRY UK
STUDY_YEAR 1989

DATA_TABLE

	Surface Area [m2]	Volume [m3]	Leakage Coeff [m3/s*Pa^n]	n	Year Built	Year Tested	Building Type	Const Type	Country	US State
UK #1	1400	4690	2.041	0.64	1964	1989	warehouse	n/a	England	n/a
UK #2	3459	15000	3.08	0.56	1979	1989	warehouse	n/a	England	n/a
UK #3	1100	3050	2.492	0.6	1984	1989	warehouse	na	England	n/a
UK #4	1694	4955	4.162	0.5	1954	1989	warehouse	masonry	England	n/a

STANDARDIZED_TABLE

	EntryID	FootprintArea	FloorArea	SurfaceArea	Volume	Nfloors	Height	Width	Length	DeltaP
UK #1	178	648	648	1400	4690	1	7.2	20.8	31.2	50
UK #2	179	2133	2133	3459	15000	1	7.0	37.7	56.6	50
UK #3	180	585	585	1100	3050	1	5.2	19.8	29.6	50
UK #4	181	1078	1078	1694	4955	1	4.6	26.8	40.2	50

NOTES	Q	n	n_Flag	Year_Built	Year_Tested	Building_Type	Const_Type	Country	US_State
Year Tested assumed ot by date of journal publication	25.0	0.64	M	1964	1989	5	n/a	England	n/a
Data reported in Table 1 of the paper	27.5	0.56	M	1979	1989	5	n/a	England	n/a
All units are har Envelope Area = 2*H*(L+W) + L*W	26.1	0.6	M	1984	1989	5	na	England	n/a
(1) Volume = H*L*W	29.4	0.5	M	1954	1989	5	1	England	n/a
(2)									

If we assume that X = 1.5
(1) and (2) redu 1.5*(W^3) - EnvelopeArea*W + 10/3*Volume = 0

	Est. W	Est. L	Est. H
	20.77852	31.16778	7.241897312
UK #1	37.71033	56.565495	7.032007645
UK #2	19.75417	29.631255	5.21063925
UK #3	26.80603	40.209045	4.597136521
UK #4			

All four buildings are factory/industrial warehouses

STUDY_ID 14
SOURCE PJ Jones, G Powell, "Reducing air infiltration losses in naturally ventilated industrial buildings", The Role of Ventilation, 15th AIVC Conference, Buxton, Great Britian, 27-30 September, 1994.
COUNTRY UK
STUDY_YEAR 1994

DATA_TABLE

	Height [m]	Surface Area [m2]	Q50 [m3/s]	Year Built	Year Tested	Building Type	Const Type	Country	US State
Unit 40	7	840	7.72	1990	1994	warehouse	metal_panels	England	n/a
Unit 41	7	840	8.17	1990	1994	warehouse	metal_panels	England	n/a
Unit 42	7	720	6.75	1990	1994	warehouse	metal_panels	England	n/a

STANDARDIZED_TABLE

	EntryID	FootprintArea	FloorArea	SurfaceArea	Volume	Nfloors	Height	Width	Length
UK #1	182	325	325	840	2274.273507	1	7.0	14.7	22.1
UK #2	183	325	325	840	2274.273507	1	7.0	14.7	22.1
UK #3	184	260	260	720	1817.044864	1	7.0	13.2	19.7

DeltaP	Q	n	n_Flag	Year_Built	Year_Tested	Building_Type	Const_Type	Country	US_State
50	7.7	0.61	M	1990	1994	5	4	England	n/a
50	8.2	0.62	M	1990	1994	5	4	England	n/a
50	6.8	0.59	M	1990	1994	5	4	England	n/a

NOTES

Year Tested assumed ot by date of journal publication
Factories decribed as "new." Year Built assumed to be 1990.
By assuming an aspect ratio of 1.5,

Surface Area = 2*H*(L+W) + L*W
Surface Area = 14*(2.5W) + 1.5W^2

Estimate n:

	Est. W	Est. L	Est. Volume
Unit 40	14.71725099	22.07587649	2274.273507
Unit 41	14.71725099	22.07587649	2274.273507
Unit 42	13.15491892	19.73237838	1817.044864

STUDY_ID 15
SOURCE Dumont, Personal Communication, 2000 (Data reported in G Proskiw, 2001 for CMHC)
COUNTRY Canada
STUDY_YEAR 2000

DATA_TABLE

Building	Surface Area [m2]	Volume [m3]	Leakage Parameter [L/s*Pa^n]	n	Year Built	Year Tested	Building Type	Const Type	Country	US State
Court house	2228	6226	423	0.56	1929	1999	public assembly	n/a	Canada	n/a
Radio station	1888	2287	132	0.63	1960	1999	small retail	n/a	Canada	n/a
Land titles build	1951	3818	82	0.68	1950	1999	small retail	n/a	Canada	n/a
Youth camp bul	1473	1753	106	0.73	1991	1999	small retail	n/a	Canada	n/a
Fire control offi	1879	1718	157	0.68	1990	1999	small retail	n/a	Canada	n/a
WB building	1136	2819	196	0.56	1975	1999	n/a	n/a	Canada	n/a
POB	1675	3265	263	0.51	1975	1999	n/a	n/a	Canada	n/a
Library	3982	9630	61	0.62	1998	1999	public assembly	n/a	Canada	n/a

STANDARDIZED_TABLE

	EntryID	FootprintArea	FloorArea	SurfaceArea	Volume	Nfloors	Height	Width	Length	DeltaP
Court house	185	1591	1591	2228	6226	1	3.9	32.6	48.8	50.0
Radio station	186	762	762	1888	2287	1	3.0	22.5	33.8	50.0
Land titles build	187	1556	1556	1951	3818	1	2.5	32.2	48.3	50.0
Youth camp bul	188	584	584	1473	1753	1	3.0	19.7	29.6	50.0
Fire control offi	189	573	573	1879	1718	1	3.0	19.5	29.3	50.0
WB building	190	701	701	1136	2819	1	4.0	21.6	32.4	50.0
POB	191	1306	1306	1675	3265	1	2.5	29.5	44.3	50.0
Library	192	3297	3297	3982	9630	1	2.9	46.9	70.3	50.0

Q	n	n_Flag	Year_Built	Year_Tested	Building_Type	Const_Type	Country	US_State
3.8	0.56	M	1929	1999	9	n/a	Canada	n/a
1.6	0.63	M	1960	1999	6	n/a	Canada	n/a
1.2	0.68	M	1950	1999	6	n/a	Canada	n/a
1.8	0.73	M	1991	1999	6	n/a	Canada	n/a
2.2	0.68	M	1990	1999	6	n/a	Canada	n/a
1.8	0.56	M	1975	1999	n/a	n/a	Canada	n/a
1.9	0.51	M	1975	1999	n/a	n/a	Canada	n/a
0.7	0.62	M	1998	1999	9	n/a	Canada	n/a

NOTES

(1) Envelope Area = 2*H*(L+W) + L*W
(2) Volume = H*L*W
If we assume that X = 1.5
(1) and (2) reduce to:
1.5*(W^3) - EnvelopeArea*W + 10/3*Volume = 0

Looks like all are 1-storey
Set H = 3m, re-estimate W by sqrt(Volume/3m/1.5)

	Est. W	Est. L	Est. H		Est. W	Est. L
Court house	32.56489	48.847335	3.913980217			
Radio station	33.25413	49.881195	1.378744284	(Too Low!)	22.5437846	33.81567684
Land titles build	32.20595	48.308925	2.453988009			
Youth camp bul	29.12465	43.686975	1.377746216	(Too Low!)	19.7371618	29.60574269
Fire control offi	33.75756	50.63634	1.005054943	(Too Low!)	19.5391345	29.30870178
WB building	21.62525	32.437875	4.018662582			
POB	29.50919	44.263785	2.499639329			
Library	46.88533	70.327995	2.920525979			

STUDY_ID 16
SOURCE Steven J Emmerich, Personal Communication
COUNTRY US
STUDY_YEAR Not Reported

Assuming an aspect ratio of x = 1.5, i.e. L = 1.5*W
Footprint= (floor area)/(# of floors)
Assuming a height of 4m/floor

Flow exponent, n, assumed to be 0.65

State	Building type	Envelope Construction	Stories	Floor area	4 Pa, C_D=1						
				ft^2	cm^2/m^2						
AL	School_1	Block/Brick	1	7200	2.760						
AL	School_2	Block/Brick	1	4322	2.560	AL	Gymn_1	Block/Brick	1	10115	2.046
AL	School_3	metal w/vapor barrier	1	20240	2.296	AL	Gymn_2		1	6000	2.152
AL	School_4		1	7200	2.855	AL	Gymn_3		2	33040	2.763
AL	School_5		1	2808	3.878	AL	Gymn_4	Block/Brick	1	13400	1.204
AL	School_6		1	6588	3.406	AL	Gym_5	Block/Brick	1	5950	1.428
AL	School_7		1	49248	1.386	AL	Gymn_6	MU w/ brick fa	1	17000	2.452
AL	School_8		1	20240	2.697	AL	Gymn_7	MU w/ brick fa	1	9504	1.824
AL	School_9		1	7200	3.795	KY	School_1	block	2	19200	1.847
AL	School_10		1	7360	2.518	KY	School_2	block	1	10100	4.004
AL	School_11		1	9152	4.678	KY	School_3	nry and alum	1	22000	4.337
AL	School_12		1	5313	3.438	KY	School_4	block	1	9272	4.828
AL	School_13		1	7200	2.855	KY	School_5	block	1	9798	2.688
AL	School_14		1	9831	4.430	KY	School_6	block	2	6616	1.926
AL	School_15		2	15120	2.630	KY	School_7	block	1	9200	4.193
AL	School_16	block	1	8200	7.424	KY	School_8	ncrete and br	1	18500	2.779
AL	School_17	block	1	9920	4.177	KY	school_9	CMU & brick	1	5917	2.887
AL	School_18	block	1	18820	3.888	KY	School_10	ncrete/ maso	2	26460	2.229
AL	School_19	block	1	12950	4.075	KY	Dorm_1	ncrete/ maso	1	8784	2.073
AL	School_20	metal w/vapor barrier	1	9028	4.403	KY	Preschool_1	block	1	3600	2.435
AL	School_21	CMU	1	9216	0.958		Preschool_2	block	1	6720	3.031
AL	School_22	CMU / Metal	1	22116	3.543	KY	Library	block	2	28000	4.936
AL	School_23	metal	1	11250	0.737	KY	Hospital	concrete and brick	5	53823	0.980
AL	School_24		4	22176	3.475	KY	r Citizen Cen	wood frame	1	787	6.499
AL	ch_1 (First and Second	metal w/vapor barrier	2	7435	5.124	KY	Nonprofit_1	block	1	1625	5.388
AL	NonProfit_1	metal w/vapor barrier	1	2891	1.682	KY	singHome - w	block	1	2250	2.487
AL	Community Center_1	metal w/vapor barrier	1	8754	1.896	KY	r Citizens Center_2		1	2260	4.719
AL	Preschool_1	Block/Brick	1	55200	1.168	KY	Auditorium_1	block	1	3150	1.666
AL	Church_2	metal w/vapor barrier	1	5850	2.347	KY	GYMN_1	block	1	6948	2.024
AL	Nursing Home_1	Block/Brick	3	11400	3.925	KY	Gymn_2	block	1	7000	5.053
AL	NonProfit_2	block	1	8445	2.805	KY	Auditorium_2	block	1	7890	3.417
AL	Nursing Home_2	Block/Brick	1	5600	2.758	KY	Gymn_3	block	1	4520	3.201
AL	Unknown	Block/Brick	1	3185	2.516	KY	RecCenter	block	1	4675	1.250
AL	Healthcare	metal w/vapor barrier	1	19610	3.179	IN	School		1	992	10.140
AL	Misc government		1	2538	6.410	IN	CourtHouse		1	2160	2.335
AL	Jail	metal w/vapor barrier	1	28418	1.569	OR	Hospital	concrete and brick	2	66000	2.291
AL	Misc military	plastic span	1	5000	4.459	CO	Unknown1	metal	1	9600	1.171
AL	Community Center _2	metal w/vapor barrier	1	5600	2.296	CO	Unknown2	stucco	1	44590	1.748

Appendix D

Apartment Building Data

APPENDIX D: APARTMENT BUILDING DATA

Title Suite Ventilation Characteristics of Current Canadian Mid- and High- Rise Residential Buildings
Author C.P. Wray
Reference ASHRAE Transactions, Vol. 106, Part 2, 2000

Study	DataEntry	CityState	Country	Year	L/(s*m2) Norm Flow	lgNormFlow	ConstN	Const	BN	Building
1	1	Vancouver	Canada	1992.5	0.57	-0.25	n/a	n/a	1	A1
1	2	Vancouver	Canada	1992.5	0.50	-0.31	n/a	n/a	2	A2
1	3	Vancouver	Canada	1992.5	0.23	-0.65	n/a	n/a	3	A3
1	4	Vancouver	Canada	1992.5	0.24	-0.62	n/a	n/a	4	A4
1	5	Toronto	Canada	1992.5	0.68	-0.17	n/a	n/a	5	A5
1	6	Toronto	Canada	1992.5	0.42	-0.38	n/a	n/a	6	A6
1	7	Winnipeg	Canada	1992.5	0.26	-0.58	n/a	n/a	7	A7
1	8	Winnipeg	Canada	1992.5	0.47	-0.33	n/a	n/a	8	A8
1	9	Winnipeg	Canada	1992.5	1.18	0.07	n/a	n/a	9	A9
1	10	Winnipeg	Canada	1992.5	0.30	-0.53	n/a	n/a	10	A10

Leakage Measurement	Units	Season	InOut	Delta T	Wind	Temp	Location	Method	Facility Discription	Site
1.63	ACH	n/a	1	21	0.56	4	Vancouver, Canada	tracer gas decay	10 buildings	building #1
1.55	ACH	n/a	1	20	0.83	5	Vancouver, Canada	tracer gas decay	10 buildings	2
0.73	ACH	n/a	1	20	0.56	5	Vancouver, Canada	tracer gas decay	10 buildings	3
0.63	ACH	n/a	1	19	0.83	6	Vancouver, Canada	tracer gas decay	10 buildings	4
1.83	ACH	n/a	1	16	4.44	9	Toronto, Canada	tracer gas decay	10 buildings	5
0.95	ACH	n/a	1	14	4.17	11	Toronto, Canada	tracer gas decay	10 buildings	6
0.6	ACH	n/a	1	24	3.33	1	Winnipeg, Canada	tracer gas decay	10 buildings	7
1.23	ACH	n/a	1	23	6.94	2	Winnipeg, Canada	tracer gas decay	10 buildings	8
2.73	ACH	n/a	1	18	4.44	7	Winnipeg, Canada	tracer gas decay	10 buildings	9
0.88	ACH	n/a	1	18	2.5	7	Winnipeg, Canada	tracer gas decay	10 buildings	10

Title Measured Airflows in a Multifamily Building
Author Lary Palmiter, Jonathan Heller, Max Sherman
Reference American Society for Testing and Materials, Philidelphia, 1995, pp. 7-22

Study	DataEntry	CityState	Country	Year	Norm Flow	lgNormFlow	ConstN	Const	BN	Building
2	11	Portland	US	1992	0.07	-1.19	n/a	n/a	11	B1
2	12	Portland	US	1992	0.08	-1.07	n/a	n/a	11	B1
2	13	Portland	US	1992	0.06	-1.23	n/a	n/a	11	B1
2	14	Portland	US	1992	0.05	-1.28	n/a	n/a	11	B1
2	15	Portland	US	1992	0.07	-1.19	n/a	n/a	11	B1
2	16	Portland	US	1992	0.10	-1.00	n/a	n/a	11	B1
LeakageMeasurement	**Units**	**Season**	**InOut**	**Delta T**	**Wind**	**Temp**	**Location**	**Method**	**Facility Discription**	**Site**
0.2	ACH	n/a	1	15.2	0.9	15.2	Portland, Oregon, U.S.	tracer tests	6 apartments in 1 3-story, 21-unit building	unit 1
0.26	ACH	n/a	1	15.2	0.9	15.2				unit 2
0.18	ACH	n/a	1	15.2	0.9	15.2				unit 3
0.16	ACH	n/a	1	15.2	0.9	15.2				unit 4
0.2	ACH	n/a	1	15.2	0.9	15.2				unit 5
0.31	ACH	n/a	1	15.2	0.9	15.2				unit 6

Title Multizone Infiltration Measurements in Homes and Buildings Using a Passive Perfourocarbon Tracer Method
Author R.N. Dietz, T.W. D'Ottavio, RW. Goodrich
Reference

Study	DataEntry	CityState	Country	Year	Norm Flow	lgNormFlow	ConstN	Const	BN	Building
3	17	LongIsland	US	n/a	0.12	-0.92	n/a	n/a	12	C1
3	18	LongIsland	US	n/a	0.32	-0.50	n/a	n/a	12	C1
3	19	LongIsland	US	n/a	0.26	-0.58	n/a	n/a	12	C1
3	20	LongIsland	US	n/a	0.26	-0.59	n/a	n/a	12	C1
Leakage Measurement	**Units**	**Season**	**InOut**	**Delta T**	**Wind**	**Temp**	**Location**	**Method**	**Facility Discription**	**Site**
0.32	ACH	n/a	1				Arizona, U.S.	tracer tests	4 apartments in 4-unit building	Unit 1
0.85	ACH	n/a	1				Arizona, U.S.	tracer tests		Unit 4
0.72	ACH	n/a	1				Arizona, U.S.	tracer tests		Unit 2
0.71	ACH	n/a	1				Arizona, U.S.	tracer tests		Unit 3

Title Air Leakage and Fan Pressurization Measurements in Selected Naval Housing
Author Peter L. Lagus, John C. King
Reference

Study	DataEntry	CityState	Country	Year	Norm Flow	lgNormFlow	ConstN	Const	BN	Building
4	31	Norfolk	US	n/a	0.25	-0.61	4	Metal	13	D1
4	32	Norfolk	US	n/a	0.25	-0.59	4	Metal	13	D1
4	33	Norfolk	US	n/a	0.26	-0.59	4	Metal	13	D1
4	34	Norfolk	US	n/a	0.45	-0.35	4	Metal	13	D1
4	35	Norfolk	US	n/a	0.66	-0.18	4	Metal	13	D1
4	36	Norfolk	US	n/a	0.34	-0.47	4	Metal	13	D1
4	37	Norfolk	US	n/a	0.17	-0.77	4	Metal	13	D1
4	38	Norfolk	US	n/a	0.23	-0.64	4	Metal	13	D1
4	39	Norfolk	US	n/a	0.36	-0.44	4	Metal	13	D1
4	40	Norfolk	US	n/a	0.16	-0.80	4	Metal	13	D1
4	41	Norfolk	US	n/a	0.19	-0.73	4	Metal	13	D1
4	42	Norfolk	US	n/a	0.15	-0.83	4	Metal	13	D1
4	43	Norfolk	US	n/a	0.31	-0.51	4	Metal	14	D2
4	44	Norfolk	US	n/a	0.27	-0.58	4	Metal	14	D2
4	45	Norfolk	US	n/a	0.38	-0.42	4	Metal	14	D2
4	46	Norfolk	US	n/a	0.41	-0.39	4	Metal	14	D2
4	47	Norfolk	US	n/a	0.69	-0.16	4	Metal	14	D2
4	48	Norfolk	US	n/a	0.29	-0.54	4	Metal	14	D2
4	49	Norfolk	US	n/a	0.18	-0.74	4	Metal	14	D2
4	50	Norfolk	US	n/a	0.32	-0.49	4	Metal	14	D2
4	51	Norfolk	US	n/a	0.32	-0.49	4	Metal	14	D2
4	52	Norfolk	US	n/a	0.25	-0.61	4	Metal	14	D2
4	53	Norfolk	US	n/a	0.17	-0.77	4	Metal	14	D2
4	54	Norfolk	US	n/a	0.16	-0.80	4	Metal	14	D2
4	55	Norfolk	US	n/a	0.24	-0.62	4	Metal	15	D3
4	56	Norfolk	US	n/a	0.62	-0.21	4	Metal	15	D3
4	57	Norfolk	US	n/a	0.46	-0.34	4	Metal	15	D3
4	58	Norfolk	US	n/a	0.22	-0.66	4	Metal	15	D3
4	59	Norfolk	US	n/a	0.26	-0.58	4	Metal	15	D3
4	60	Norfolk	US	n/a	0.21	-0.68	4	Metal	15	D3
4	61	Norfolk	US	n/a	0.15	-0.83	4	Metal	15	D3

Title Air Leakage and Fan Pressurization Measurements in Selected Naval Housing
Author Peter L. Lagus, John C. King
Reference

Study	DataEntry	CityState	Country	Year	Norm Flow	lgNormFlow	ConstN	Const	BN	Building
4	62	Norfolk	US	n/a	0.17	-0.76	4	Metal	15	D3
4	63	Norfolk	US	n/a	0.27	-0.57	4	Metal	15	D3
4	64	Norfolk	US	n/a	0.28	-0.56	4	Metal	15	D3
4	65	Norfolk	US	n/a	0.22	-0.67	4	Metal	15	D3
4	66	Norfolk	US	n/a	0.14	-0.84	4	Metal	15	D3
4	67	Norfolk	US	n/a	0.34	-0.47	4	Metal	16	D4
4	68	Norfolk	US	n/a	0.68	-0.16	4	Metal	16	D4
4	69	Norfolk	US	n/a	0.75	-0.12	4	Metal	16	D4
4	70	Norfolk	US	n/a	0.24	-0.62	4	Metal	16	D4
4	71	Norfolk	US	n/a	0.25	-0.61	4	Metal	16	D4
4	72	Norfolk	US	n/a	0.27	-0.57	4	Metal	16	D4
4	73	Norfolk	US	n/a	0.14	-0.85	4	Metal	16	D4
4	74	Norfolk	US	n/a	0.15	-0.81	4	Metal	16	D4
4	75	Norfolk	US	n/a	0.28	-0.55	4	Metal	16	D4
4	76	Norfolk	US	n/a	0.27	-0.56	4	Metal	16	D4
4	77	Norfolk	US	n/a	0.18	-0.74	4	Metal	16	D4
4	78	Norfolk	US	n/a	0.11	-0.95	4	Metal	16	D4

Leakage Measurement	Units	Season	InOut	Delta T	Wind	Temp	Location	Method	Facility Discription	Site
0.94	ACH	1	1	2	2.3	23	Norfolk, Virginia and Pensacola, Florida, U.S.	pressurization, then converted	24 units in 4 sixplexes and 2 units in 1 duplex	building 108, unit 8118
0.97	ACH	1	1	1	2.3	24				
0.99	ACH	1	1	1	4.5	26				
1.7	ACH	1	1	8	8.9	17				building 108, unit 8121
2.5	ACH	1	1	15	10.5	10				building 108, unit 8122
1.3	ACH	1	1	18	5.4	7				building 108, unit 8123
0.64	ACH	2	1	20	2	5				building 108, unit 8118
0.87	ACH	2	1	23	2.8	2				building 108, unit 8119
1.39	ACH	2	1	24	3.6	1				building 108, unit 8120
0.6	ACH	2	1	24	2.4	1				building 108, unit 8121
0.71	ACH	2	1	21	2.4	4				building 108, unit 8122
0.56	ACH	2	1	17	1.8	8				building 108, unit 8123
1.17	ACH	1	1	2	2.3	23				building 114, unit 8160
1.01	ACH	1	1	4	2.3	21				building 114, unit 8161
1.45	ACH	1	1	0	4.5	25				building 114, unit 8162

Title Air Leakage and Fan Pressurization Measurements in Selected Naval Housing
Author Peter L. Lagus, John C. King
Reference

Leakage Measurement	Units	Season	InOut	Delta T	Wind	Temp	Location	Method	Facility Discription	Site
1.57	ACH	1	1	5	8.9	20	Norfolk, Virginia and Pensacola, Florida, U.S.	pressurization, then converted		building 114, unit 8163
2.63	ACH	1	1	9	10.5	16				building 114, unit 8164
1.09	ACH	1	1	19	5.6	6				building 114, unit 8165
0.7	ACH	2	1	16	2	9				building 114, unit 8160
0.73	ACH	2	1	18	2.8	7				building 114, unit 8161
1.23	ACH	2	1	23	3.6	2				building 114, unit 8162
0.94	ACH	2	1	23	2.4	2				building 114, unit 8163
0.64	ACH	2	1	22	2.4	3				building 114, unit 8164
0.6	ACH	2	1	18	1.8	7				building 114, unit 8165
0.92	ACH	1	1	18	5.6	7				building 110, unit 8130
2.35	ACH	1	1	10	10.5	15				building 110, unit 8131
1.75	ACH	1	1	4	8.9	21				building 110, unit 8132
0.84	ACH	1	1	0	4.5	25				building 110, unit 8133
1	ACH	1	1	1	2.3	24				building 110, unit 8134
0.79	ACH	1	1	1	2.3	26				building 110, unit 8135
0.57	ACH	2	1	19	1.8	6				building 110, unit 8130
0.66	ACH	2	1	22	2.4	3				building 110, unit 8131
1.02	ACH	2	1	24	3.6	1				building 110, unit 8132
1.05	ACH	2	1	24	3.6	1				building 110, unit 8133
0.82	ACH	2	1	18	2.8	7				building 110, unit 8134
0.55	ACH	2	1	21	2	4				building 110, unit 8135
1.28	ACH	1	1	17	5.6	8				building 112, unit 8148
2.61	ACH	1	1	10	10.5	15				building 112, unit 8149
2.87	ACH	1	1	6	8.9	19				building 112, unit 8150
0.91	ACH	1	1	2	4.5	23				building 112, unit 8151
0.94	ACH	1	1	2	2.3	23				building 112, unit 8152
1.02	ACH	1	1	3	2.4	28				building 112, unit 8153
0.54	ACH	2	1	17	1.8	8				building 112, unit 8148
0.59	ACH	2	1	23	2.4	2				building 112, unit 8149
1.07	ACH	2	1	20	3.6	5				building 112, unit 8150
1.04	ACH	2	1	24	3.6	1				building 112, unit 8151
0.69	ACH	2	1	19	3.1	6				building 112, unit 8152
0.43	ACH	2	1	16	2	9				building 112, unit 8153

Airtightness Survey of Row Houses in Calgary, Alberta

James A. Love

American Society for Testing and Materials, Philidelphia, 1990, pp. 194-210

Study	DataEntry	CityState	Country	Year	NormFlow L/(s*m2) at 50Pa	lgNormFlow	ConstN	Const	BN	Building
5	1	Calgary	Canada	1967.5	2.13	0.33	1	Wood	17	E1
5	2	Calgary	Canada	1967.5	2.13	0.33	1	Wood	17	E1
5	3	Calgary	Canada	1967.5	2.07	0.32	1	Wood	17	E1
5	4	Calgary	Canada	1967.5	1.67	0.22	1	Wood	18	E2
5	5	Calgary	Canada	1967.5	1.50	0.17	1	Wood	19	E2
5	6	Calgary	Canada	1967.5	2.24	0.35	1	Wood	19	E3
5	7	Calgary	Canada	1973.5	0.92	-0.04	1	Wood	20	E4
5	8	Calgary	Canada	1973.5	0.97	-0.01	1	Wood	21	E4
5	9	Calgary	Canada	1973.5	1.04	0.02	1	Wood	22	E4
5	10	Calgary	Canada	1973.5	2.59	0.41	1	Wood	21	E5
5	11	Calgary	Canada	1973.5	2.34	0.37	1	Wood	22	E5
5	12	Calgary	Canada	1982	2.26	0.35	1	Wood	22	E6
5	13	Calgary	Canada	1982	2.79	0.45	1	Wood	23	E6
5	14	Calgary	Canada	1982	1.92	0.28	1	Wood	24	E6
5	15	Calgary	Canada	1982	2.07	0.32	1	Wood	25	E6
5	16	Calgary	Canada	1982	1.28	0.11	1	Wood	26	E6
5	17	Calgary	Canada	1982	2.21	0.34	1	Wood	27	E6
5	18	Calgary	Canada	1982	2.55	0.41	1	Wood	28	E6
5	19	Calgary	Canada	1982	1.34	0.13	1	Wood	29	E6
5	20	Calgary	Canada	1982	2.67	0.43	1	Wood	23	E7
5	21	Calgary	Canada	1982	3.74	0.57	1	Wood	24	E7
5	22	Calgary	Canada	1982	3.74	0.57	1	Wood	25	E7
5	23	Calgary	Canada	1982	3.16	0.50	1	Wood	26	E7
5	24	Calgary	Canada	1982	3.83	0.58	1	Wood	27	E7

Airtightness Survey of Row Houses in Calgary, Alberta

James A. Love

American Society for Testing and Materials, Philidelphia, 1990, pp. 194-210

Method	Site	Leakage Measurement	Units	Flow	Volume	Facility Discription
fan depressurization	building 1, unit 1E (1-1E)	3.4	ACH at 50Pa	1278.4	376	42 row houses from 9 complexes
fan depressurization	1-4E	3.4	ACH at 50Pa	1278.40	376	42 row houses from 9 complexes
fan depressurization	1-5	2.4	ACH at 50Pa	902.40	376	42 row houses from 9 complexes
fan depressurization	2-1E	2.8	ACH at 50Pa	904.40	323	42 row houses from 9 complexes
fan depressurization	2-2E	2.5	ACH at 50Pa	807.50	323	42 row houses from 9 complexes
fan depressurization	3-1E	4.6	ACH at 50Pa	910.80	198	42 row houses from 9 complexes
fan depressurization	5-1	5.4	ACH at 50Pa	518.40	96	42 row houses from 9 complexes
fan depressurization	5-2	5.7	ACH at 50Pa	547.20	96	42 row houses from 9 complexes
fan depressurization	5-3	6.1	ACH at 50Pa	585.60	96	42 row houses from 9 complexes
fan depressurization	6-2	3.2	ACH at 50Pa	1136.00	355	42 row houses from 9 complexes
fan depressurization	6-3	2.9	ACH at 50Pa	1029.50	355	42 row houses from 9 complexes
fan depressurization	7-2	3.9	ACH at 50Pa	1450.80	372	42 row houses from 9 complexes
fan depressurization	7-3	4.8	ACH at 50Pa	1785.60	372	42 row houses from 9 complexes
fan depressurization	7-4E	3.8	ACH at 50Pa	1413.60	372	42 row houses from 9 complexes
fan depressurization	7-5E	4.1	ACH at 50Pa	1525.20	372	42 row houses from 9 complexes
fan depressurization	7-6	2.2	ACH at 50Pa	818.40	372	42 row houses from 9 complexes
fan depressurization	7-7	3.8	ACH at 50Pa	1413.60	372	42 row houses from 9 complexes
fan depressurization	7-8	4.4	ACH at 50Pa	1636.80	372	42 row houses from 9 complexes
fan depressurization	7-9	2.3	ACH at 50Pa	855.60	372	42 row houses from 9 complexes
fan depressurization	9-1E	3.8	ACH at 50Pa	1257.80	331	42 row houses from 9 complexes
fan depressurization	9-2	3.9	ACH at 50Pa	1290.90	331	42 row houses from 9 complexes
fan depressurization	9-3	3.9	ACH at 50Pa	1290.90	331	42 row houses from 9 complexes
fan depressurization	9-4	3.3	ACH at 50Pa	1092.30	331	42 row houses from 9 complexes
fan depressurization	9-5	4	ACH at 50Pa	1324.00	331	42 row houses from 9 complexes

Valuing Air Bariers

Duncan Hill Home Energy, Sept./Oct. 2001, pp. 29-32

Study	DataEntry	CityState	Country	Year	NormFlow	lgNormFlow	ConstN	Const	BN	Building
8	32	na	Canada	na	3.07	0.49	n/a	n/a	24	F1

Location	Method	cility Discripti	Site	Leakage Measurement	Units
Canada	not reported	3 buildings	ɔr all 3 buildings	4	L/s*m2 at 75Pa

Field Investigation Survey of Airtightness, Air Movement, and Indoor Air Quality in High Rise Apartment Buildings

B.W. Gulay, C.D. Stewart, G.J. Foley Summary Report for Canada Mortgage and Housing Corporation

Study	DataEntry	CityState	Country	Year	NormFlow	lgNormFlow	ConstN	Const	BN	Building
9	33	Atlantic	Canada	1982	6.30	0.80	n/a	n/a	25	G1
9	34	Atlantic	Canada	1982	7.80	0.89	n/a	n/a	25	G1
9	35	Atlantic	Canada	1982	7.80	0.89	n/a	n/a	25	G1
9	36	Atlantic	Canada	1982	7.40	0.87	n/a	n/a	25	G1
9	37	Quebec	Canada	1991	2.20	0.34	2	Brick	26	G2
9	38	Quebec	Canada	1960	4.58	0.66	2	Brick	27	G3
9	39	Praries	Canada	1973	2.50	0.40	2	Brick	28	G4
9	40	Praries	Canada	1973	7.03	0.85	2	Brick	28	G4
9	41	Praries	Canada	1973	8.33	0.92	2	Brick	28	G4
9	42	Praries	Canada	1970	3.15	0.50	2	Brick	29	G5
9	43	Praries	Canada	1970	3.11	0.49	2	Brick	29	G5
9	44	Praries	Canada	1970	2.10	0.32	2	Brick	29	G5

Facility Discription	Leakage Measurement	Units	Method	Site
10 buildings	6.3	L/s*m2 at 50Pa	fan depressurization	Atlantic, building 1, unit #501
10 buildings	7.8	L/s*m2 at 50Pa	fan depressurization	Atlantic, building 1, unit #503
10 buildings	7.8	L/s*m2 at 50Pa	fan depressurization	Atlantic, building 1, unit #505
10 buildings	7.4	L/s*m2 at 50Pa	fan depressurization	Atlantic, building 1, unit #507
10 buildings	2.2	L/s*m2 at 50Pa	fan depressurization	Quebec, Building 1, single unit
10 buildings	4.58	L/s*m2 at 50Pa	fan depressurization	Quebec, Building 2, single unit
10 buildings	2.5	L/s*m2 at 50Pa	fan depressurization	Praries, Building A, unit 405
10 buildings	7.03	L/s*m2 at 50Pa	fan depressurization	Praries, Building A, unit 409
10 buildings	8.33	L/s*m2 at 50Pa	fan depressurization	Praries, Building A, unit 909
10 buildings	3.15	L/s*m2 at 50Pa	fan depressurization	Praries, Building B, unit 509
10 buildings	3.11	L/s*m2 at 50Pa	fan depressurization	Praries, Building B, unit 609
10 buildings	2.1	L/s*m2 at 50Pa	fan depressurization	Praries, Building B, unit 1009

Airtightness Testing and Air Flow Modeling of a Three-Unit Multifamily Building

Sebastiano DePani, Paul Fazio

The Canadian Conference on Building Energy Simulation, Proceedings, June 13-14, 2001

Study	DataEntry	CityState	Country	Year	NormFlow	lgNormFlow	ConstN	Const	BN	Building
10	45	Montreal	Canada	1969	6.97	0.84	n/a	n/a	30	H1
10	46	Montreal	Canada	1969	7.79	0.89	n/a	n/a	30	H1
10	47	Montreal	Canada	#REF!	5.83	0.77	n/a	n/a	30	H1
10	48	Montreal	Canada	1969	11.11	1.05	n/a	n/a	30	H1

Facility Discripti	Site	Leakage Measurement	Units	Flow	Volume	Method
1, 3-unit building	entire building	12.6	ACH at 50Pa	11226.60	891	fan depressurization
1, 3-unit building	ınit 1 to exterior	10.5	ACH at 50Pa	4620.00	440	fan depressurization
1, 3-unit building	ınit 2 to exterior	15.8	ACH at 50Pa	5198.20	329	fan depressurization
1, 3-unit building	ınit 3 to exterior	11.5	ACH at 50Pa	1403.00	122	fan depressurization

Methods for Measuring Air Leakage in High-Rise Apartments

Chia-yu Shaw, Simona Gasparetto, James T. Reardon

American Society for Testing and Materials, Philadelphia, 1986, pp. 5-16

Study	DataEntry	CityState	Country	Year	NormFlow	lgNormFlow	ConstN	Const	BN	Building
12	51	na	Canada	1982	3.60	0.56	3	Concrete	31	I1
12	52	na	Canada				3	Concrete	31	I1

Method	Site	Leakage Measurement	Units	Facility Discription
fan	building V, single apartment	3.6	L/s*m2 at 50Pa	2 buildings connected at ground floor
fan	building B, single apartment	2.4	L/s*m2 at 50Pa	2 buildings connected at ground floor

Balanced Fan Depressurization Method for Measuring Component and Overall Air Leakage in Single and Multifamily Dwellings

J.T. Reardon, A.K. Kim, C.Y. Shaw

American Society for Testing and Materials, Philadelphia, 1990, pp. 220-230

Study	DataEntry	CityState	Country	Year	NormFlow	lgNormFlow	ConstN	Const	BN	Building
13	53	na	Canada	na	4.50	0.65	2	Brick	32	J1
13	54	na	Canada	na	3.10	0.49	1	Wood	33	J2
13	55	na	Canada	na	2.29	0.36	1	Wood	34	J3
13	56	na	Canada	na	3.43	0.54	2	Brick	35	J4

Facility Discription	Leakage Measurement	Units	Flow	Volume	Method	Site
2 row houses, 2 & 4 stories, 3 units each 2 stories	7	ACH at 50Pa	2625.00	375	fan depressurization	unit R1
2 row houses, 2 & 4 stories, 3 units each 2 stories	3.5	ACH at 50Pa	728.00	208	fan depressurization	unit R2
2 row houses, 2 & 4 stories, 3 units each 2 stories	5	ACH at 50Pa	1370.00	274	fan depressurization	unit R3
2 row houses, 2 & 4 stories, 3 units each 2 stories	7.5	ACH at 50Pa	3900.00	520	fan depressurization	unit A1

Case Study of Ventilation Improvements in a Multifamily Building

Proceedings 1992 ACEEE Summer Study, vol. 2

Mark Kelly, John McQuail, Robert O'Brien

Study	DataEntry	CityState	Country	Year	NormFlow	lgNormFlow	ConstN	Const	BN	Building
6	25	n/a	US	n/a	1.6	0.20	n/a	n/a	36	K1
6	26	n/a	US	n/a	3.6	0.56	n/a	n/a	37	K2
6	27	n/a	US	n/a	2.2	0.34	n/a	n/a	38	K3

Location	Facility Discripti	Site	Method
US	5 story building	building A	fan depressurization
US	17 story building	building V	fan depressurization
US	14 story building	building D	fan depressurization

Diagnostics and Measurements of Infiltration and Ventilation Systems in High-Rise Apartment Buildings

Helmut E. Feustel, Richard C. Diamond

Study	DataEntry	CityState	Country	Year	NormFlow	lgNormFlow	ConstN	Const	BN	Building
7	28	Oakland	US	1968	2.80	0.45	3	Concrete	39	L1
7	29	Oakland	US	1968	3.13	0.49	3	Concrete	39	L1
7	30	Oakland	US	1977	6.63	0.82	3	Concrete	40	L2
7	31	Oakland	US	1977	6.32	0.80	3	Concrete	40	L2

Facility Discription	Site	Leakage Measurement	Units	Flow	Volume	Method
building 2	unit #1015	3.80	ACH at 50Pa	445.00	117	fan depressurization
building 2	unit #503	5.07	ACH at 50Pa	416.00	82	fan depressurization
building 3	unit # 826	8.71	ACH at 50Pa	1089.00	125	fan depressurization
building 3	unit #1134	8.30	ACH at 50Pa	1038.00	125	fan depressurization

Implementing the Results of Ventilation Research

Stephen N. Flanders

16th AIVC Conference, September, 1995

Study	DataEntry	CityState	Country	Year	NormFlow	lgNormFlow	ConstN	Const	BN	Building
11	49	Kansas	US	n/a	4.52	0.66	4	Metal	41	M1
11	50	Kansas	US	n/a	7.17	0.86	4	Metal	41	M1

Method	Site	Leakage Measurement	Units	Facility Discription
fan	"guarded" avg. for end apartments	10.5	ACH at 50Pa	3 building with 3 units each - 7 units tested
fan	"guarded" avg. for middle apartments	12.5	ACH at 50Pa	3 building with 3 units each - 7 units tested